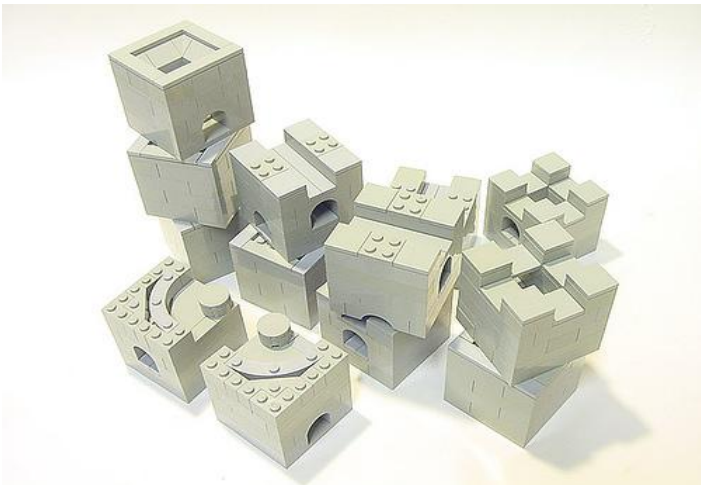
UNIVERSITY OF PIRAEUS

Department of Banking & Financial Management

Postgraduate part-time programme in Financial Analysis

"Interest rate, Equity, FX and Commodity linked Structured Products: Overview and Performance"



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Chapter 1: Introduction

1.1 What are Structured Products

Structured products have become very popular during the last two decades and at the same time the focus of much attention, following highly publicized losses sustained by investors caught off guard by the recent reversal in the trend of interest rates.

Although structured products have existed for many years, there is no universally agreed definition. This reflects the wide variety of products that exist now days, including an increasing number of products tailored to meet individual requirements of investors and moreover the constant innovation that features this market. In this paper we give a general definition based on the way a structured product is built.

Structured products include all financial products issued to the public by financial institutions that combine at least two financial instruments. They are usually composed of identifiable building blocks. The debt component of the product is equivalent to a bond and the derivative component is equivalent to a long-term option. The option or the options included in the note offer customized payoff to the investor spanning from portfolio safety to enhanced yields (Braddok, 1997).

1.2 The Origin of Structured Products

Structured products became widely used in the U.S. during the 1980s and were introduced in Europe in the mid 1990s, during years of low interest rates. The zero coupon bond that typically is the base of a structured product issue was first introduced in the United States by J.C Penney Company in 1981. (Frohm, 2005)

Structured investments arose from the need of companies which want to raise capital more cheaply. Traditionally, one of the ways to do this was to issue a convertible bond, that is, debt that under certain circumstances could be converted to equity. In exchange for the potential for

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a higher return (if the equity value would increase and the bond could be converted at a higher profit), investors would accept lower interest rates in the meantime.

However this trade off and its actual worth were debatable, since the movement of the equity value of a company could be unpredictable. Investment Banks, (financial institutions which assist other companies issue bonds to raise capital) then decided to add features to the basic convertible bond, such as increased income in exchange for limits on the convertibility of the stock, or principal protection. These extra features were all based around strategies investors themselves could perform using options and other derivatives, except that they were pre-packaged as one product. The goal was again to give investors more motivation to accept a lower interest rate on debt in exchange for certain features. On the other hand, the goal for the investment banks was to increase profit margins since the newer products with added features were harder to value, so that it was harder for the banks' clients to see how much profit the bank was making from it.

In recent years, interest rates in these investments have been growing and high net worth investors now use structured products as way of portfolio diversification. Structured products are also available at the mass retail level - particularly in Europe, where national post offices, and even supermarkets, sell investments on to their customers.

According to the Structured Products Association (SPA), structured products are the fastest growing investment class in United States (April 2007). Last year, American investors purchased $64.3 billion in these products, 32% up from the previous year's $48.7 billion total. In the first quarter of 2007, there where 1.179 new structured notes, issued by nearly 25 providers. This is nearly half the 3.300 structured products issued in 2006[1]. In Europe, issuance is much more developed, with approximately $196 billion in 2006, up from around $135 billion in 2004[2].

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[1] Source www.structuredretailproduct.com, retrieved May 2007.
[2] Source "U.S. Structured Products Market: Will 2007 be the industries first $100 billion Year?", Keith A. Styrcula, Structured Products Association, April 2007.

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1.3 <u>The Structure of the study</u>

This paper will introduce common structured products and explain how these products are designed via financial engineering, categorize them and identify their benefits and risks both from the issuer's as well as from the investor's perspective. Although this paper concentrates only on a limited number of structured products from an exhausted list of the numerous types of structured products that have been created, yet our intention is to raise investor's awareness about common structures. Furthermore, we will look into the analysis and the progress so far of the pricing models and methods used for structured products and explain why is difficult to adopt an appropriate pricing model. Thereafter, we will introduce and analyze twelve capital guaranteed structured products, structured upon four different underlying assets. We will specify their characteristics and payoff functions and look into the motivation on each category. Moreover, we will observe the interrelation among each product's underlying asset summary statistics and the performance of the structured products and finally make some conclusions and comments on these results.

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Chapter 2: How Structured Products are designed

A structured product is created through the process of financial engineering. As mentioned in the first section of this chapter, it comprises of two components, **a risk free asset element,** and **an option element**. The risk free asset element is used to guarantee the return of the initial capital at maturity or to provide a regular income stream whilst the second component, that is an option, gives exposure to the selected underlying security and allows the implementation of a strategy that reflects expected market conditions.

On a 100% principal guaranteed at maturity product the initial allocation of the capital on the risk free element depends on the interest rates while the allocation on options is called Discount interest and is the residual of the total capital invested.

During the lifetime of the investment, both components are sensitive to various market parameters. The risk free asset element is sensitive to interest rates. The option element is mainly sensitive to the following parameters:

- Volatility
- Underlying asset value
- Dividends
- Interest rates
- Remaining time to maturity

2.1. Risk-free asset element

The risk free element is equivalent to a zero coupon bond and provides the guarantee of the initial capital. To understand the mechanics of it we will look at a simple growth structured product that offers 100% capital protection and simultaneously a FTSE 100 Index exposure over a fixed five-year period. This can be broken down into two elements (supposing that there are no commissions or other expenses):

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- A zero coupon bond that pays out 100% of the initial investment after five years
- A five-year FTSE 100 call option

The bond element absorbs by far the largest part of the investment. If we assume an interest rate of 5%, then it will account for approximately 77% of the total investment[3]. That is, the zero coupon bond is currently worth 77% of the initial investment and is guaranteed to be worth 100% in a five-year time. That leaves 23% for the option element (Figure 1).

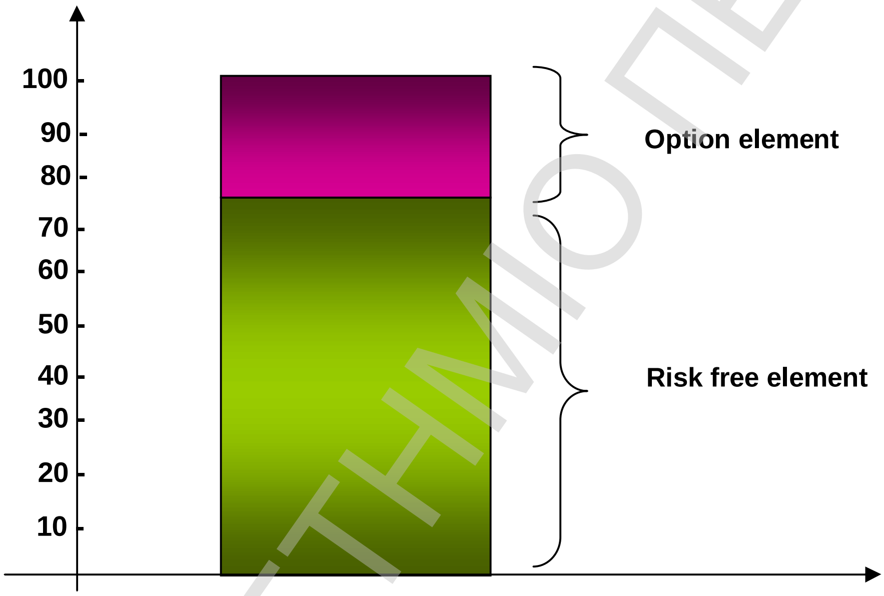

Figure 2.1 Pattern of a plain vanilla structured product

The above example illustrates why during the lifetime of the investment, the risk free asset element is highly sensitive to interest rates variations. If interest rates fall, its value increases whereas if interest rates rise, its value decreases. The sensitivity to interest rates of a 100% principal guaranteed investment is equivalent to the sensitivity of a zero coupon bond with same maturity. This conclusion stands when the investment offers no guaranteed coupon; otherwise zero coupon's sensitivity is lower.

[3] We took as example the EIB 0 11/12/12 zero coupon bond, ISIN XS0263189127, Source Bloomberg.

2.2. Option element

Options are at the heart of most structured products. Although certain products entail short positions in options, most structured products are build on long positions in options and so, for the purposes of this paper we will analyze long positions in options, as well. Basically, option is the right to buy or sell an asset at a fixed price on a predetermined date. The right to buy is called” call option” while the right to sell is called “put option”. The buyer of the option, regardless weather it is a call or a put option, pays a premium for that right, but is under no obligation to buy the option if it is not worthwhile to do so.

For example if an investor expects the FTSE 100 Index to be 10% higher in three months time, than he would buy today a three-month FTSE 100 Index **call option** that would give him the right to buy, at the end of the three months, the FTSE 100 Index at the current market level. If the FTSE 100 Index falls, then there is no point in exercising the call option and the investor has lost the premium he paid at the beginning. If the FTSE 100 rises over the period, the investor makes a profit since he is able to buy the FTSE 100 Index at the original level through the call option and sell it at a higher price.

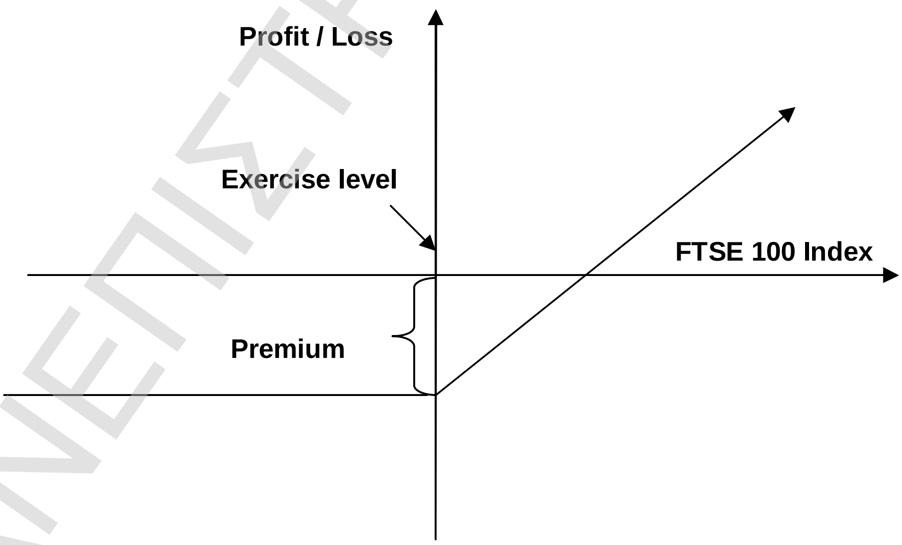

Figure 2.2 Profit / Loss Diagram of Long position in a call option

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Similarly, an investor that believes that the FTSE 100 Index will decrease 10% in the next three months, he would buy a **put option** on the FTSE 100 Index exercisable at the current market level.

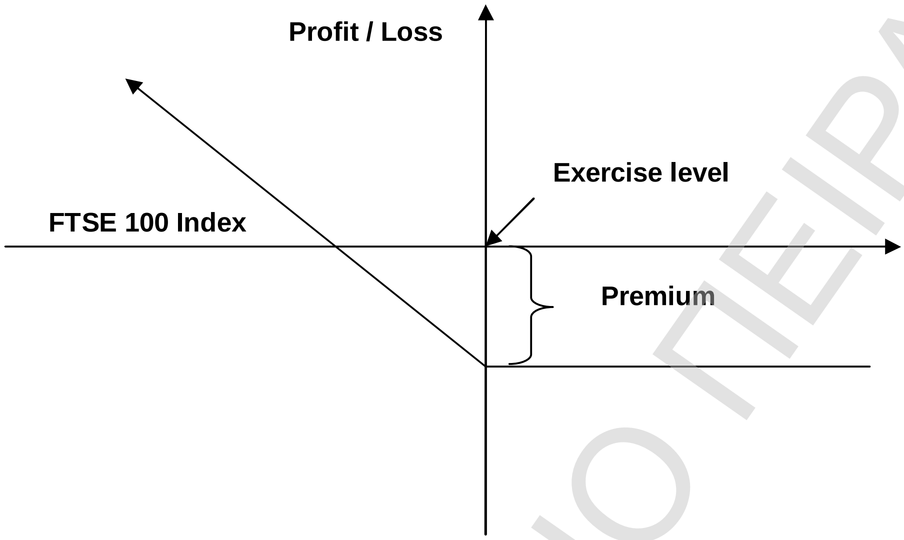

Figure 2.3 Profit / Loss Diagram of Long position in a put option

If the market does not fall, then at the end of the three months, the investor looses the premium he paid. If the market falls over the period, the investor makes a profit with which he would also off set the premium he paid originally.

The above examples of call and put options, make obvious that the option component of a structured product provides the participation to the underlying asset at maturity and is mainly sensitive to two market parameters,

- **Volatility of the underlying asset**
- **Changes in spot price of the underlying asset**

Volatility can be defined as a measure reflecting the width of price fluctuations of the underlying asset during a certain period of time. There are three main categories:

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ü Historical

ü Implied

ü Realized

For the purposes of our analysis, we are going to analyze historical volatility, which is calculated on the basis of historical returns of the underlying asset and is therefore impacted by the frequency and the duration of measures. Historical volatility is expressed by the standard deviation of the returns divided by the squared root of the length of the time period in years. It is a measure of the degree to which the underlying asset fluctuates in relation to its mean return, namely the average return of an asset over a period of time.[4] When the volatility of an underlying asset increases, then the value of options on this underlying asset increases, and vice versa.

Spot price variations generate fluctuations of the option price. A rise in the underlying asset value will lead to a rise in the price of a call option and similarly a drop in the underlying asset value will lead to a drop in the call option price. This parameter can be interpreted as the probability of the option delivering some return in maturity. Moreover, the spot price fluctuations have the adverse results for a put option.

The option component is also sensitive to additional factors, such as the:

- Interest rate level
- Dividend yield of the underlying
- Remaining time to maturity

Interest rate levels have an impact on the option component. In the case of long positions in call options, when short-term interest rates increase, the price of the call option will increase, since a trader will have to borrow cash at a higher price to hedge his position. Respectively, if

[4] For more information see APPENDIX 1

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short-term interest rates decrease, the price of the call option will decrease as well. Here as well, interest rate fluctuations have opposite results for the buyer of a put option.

The level of the dividend yield has also an impact on the option price. Increasing dividend yields will decrease the price of the call option and increase the price of a put option since spot price will decrease and increase, respectively Similarly, a decreasing dividend yield shall have the reverse results.

Finally, the remaining lifetime of the option affects option's price. An option is a perishable asset, that is to say the longer is the remaining lifetime, the higher the time value and therefore the premium of the option. The loss in time value is steeper as the option approaches maturity. For an American call or put option[5] price increases as time to maturity increases.

[5] American options are options that can be exercised anytime during the lifetime of the options, while European options can only be exercised on the expiration date.

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Chapter 3: Classification of Structured Products

With regards to classification, structured products are not homogenous, since a wide range of asset classes and payoff patterns can be used to compose them, and thus, numerous combinations can be made to serve investor's needs. Though the investor and the issuer can mutually agree upon any type of structure, some designs have become more popular. Below we will analyze and discuss commonly used types of structured products. For the purposes of this study we divided up the products in categories based on factors mentioned below:

- **The existence or not of principal protection,**
- **The underlying benchmark their performance is linked to, recognizing four major subcategories and**
- **The special features of their payoff functions, subdividing them into six generalized categories**.

3.1 Classification based on the existence of principal protection:

One form of classification involves dividing up the products into those **with principal protection** and those without. The products that offer principal protection typically guarantee the repayment of a pre-defined percentage of the initial capital and at the same time allow investors profit from the performance of the underlying instrument. On the other hand, products **without principal protection** give the investor the chance to receive realized enhanced returns but do not guaranteed the initial capital.

3.2 Classification based on the Underlying benchmark their performance is linked to:

3.2.1 **Interest rate-linked Notes**: Interest rate-linked Notes return is based upon the movement of an interest rate index such as Libor, Constant Maturity Treasury rates, Constant Maturity Swaps etc. These notes will pay a coupon only if the conditions of the note are met and/ or maintained. In many cases, if the condition is not maintained there will be no coupon cash flow. Additionally, some coupon may not be paid until maturity.

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3.2.2 **Equity-Linked Notes**: An Equity-linked Note pays a coupon linked to the performance of one equity or a basket of equities over a predefined time period. On the termination date, the note pays the initial principal amount plus a coupon, if any, based on the percentage change in the underlying stock.

3.2.3 **Foreign Exchange-Linked Notes:** These types of Currency-linked Notes' return is linked to a foreign exchange market or a selected basket of currencies. It is usually a relatively short-term note; its return is based on the movement in the foreign exchange rates of the selected market or currency basket over the life of the note. Some notes may pay a coupon periodically or at maturity. Additionally some notes provide principal protection if held to maturity or call date.

3.2.4 **Commodity-Linked Notes:** A Commodity-linked Note's return is linked to the performance of a commodity or basket of commodities over a defined period. On the maturity date, the note pays the initial invested amount plus a return based on the percentage change in the underlying commodity/ or basket of commodities. Commodities include crude oil, heating oil, gasoline, natural gas, copper, gold, silver etc.

3.3 Classification based on the special features of their payoff functions:

3.3.1 **Step Ups / Multi Steps:** These are notes callable from the issuer, that usually pay an initial enhanced yield compared to a benchmark bond of a comparable maturity and have coupon that rise, or in other words step-up, at predetermined points of time. In the occasion that the coupon has more than one adjustment period, then the product is knows as Multi step. Multi step products can also be thought as one-way floaters, since the coupon can adjust higher but never lower.

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3.3.2 **Index-Amortizing Notes:** An index-amortizing note (IAN) is a form of structured note for which the outstanding principal amortizes according to a predefined schedule. This schedule is linked to the level of a designated index (Libor, Euribor, CMS etc) and consequently the timing of future return and thus the average life and the yield to maturity of the product, becomes uncertain. Yet, the IAN does have a stated maximum maturity date at which the entire remaining principal must be retired.

3.3.3 **Dual Index Notes:** A dual index note is a structured product whose coupon is based on the spread between two market indices. The most popular indices used in this type of notes are Libor, Euribor and CMS rates of different maturities. An investor that buys a DIN is typically making an assumption about the steepening or the flattening of the yield curve. An example of these notes, that would be suitable for an investor which has a view that the yield curve will flatten, would be one with a coupon that is based on the spread between the

10year CMS rate – the 2year CMS + a designated spread.

According to this formula, the note will return high interest if the yield flattens between those two swap rates.

3.3.4 **De-Leveraged and Leveraged Floaters:** These types of products give the investor the opportunity to receive an above the market rate of return and tie subsequent coupon adjustments to a specific point of on the yield curve. A leveraged note’s coupon will adjust by a multiple of a change in the underlying interest rate, for example 2,25 * 3M Libor + 45bps, while a de-leveraged note’s coupon will adjust by a fraction of a rate change, e.g. 0,5 * 10year CMS + 80bps. These structures can become really costly if original assumptions prove incorrect, especially if they are long-term notes.

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3.3.5 **Range Accrual Notes:** Range accrual notes (RAN) return interest daily at a set coupon which is tied to an index. Most RANs have two coupon levels. The higher coupon rate is for the period that the index remains within the ranges, the lower rate is used during periods that the index exceeds the ranges. Sometimes the lower coupon could be zero. Most RANs reference the index daily, hence there are many that reference monthly, quarterly or even once in the lifetime of the note. It is apparent that the narrowest is the range, the greater the potential interest, since the investor is rewarded for the additional risk he takes.

3.3.6 **Inverse Floaters:** This type of note is designed so that its coupon varies inversely with a designated index. In other words, when the index increases, the coupon of the note declines and vice versa. Inverse floaters can be structured using any index.

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Chapter 4: Motivation and Risks of Structured Products

4.1. Motivation on Structured Products

As already mentioned, structured products are synthetic investment instruments, specially created to meet specific needs that cannot be met by the standardized financial instruments available in the markets, which fact makes them popular. Below we summarize some of their basic **benefits** over traditional investments, from an investor's perspective:

Principal protection: Structured products can offer an investor the comfort of either 100% or a determined level of principal protection at maturity. This means that the investor knows at the outset of the investment the minimum amount that he will receive upon termination of the product. After assessing the structured product's terms, the investor can at least be certain of the best and worst case outcomes. Yet, the investor has to take into account that the protection commitment is made to maturity, not at some point before.

Most structured products offer principal guarantee, consequently this feature has become so common that its importance is often been overlooked. A good example is when, between summer of 2000 and spring of 2003, the MSCI World Index lost about half of its value.[6] Principal guarantee structured products were able to recover 100% of an investor's capital over that period. This example makes it clear why structured products are attractive to investors with clearly identified maximum loss limits.

Diversification: Structured products are effective diversification tools due to their exposure to market parameters inaccessible using traditional fund management. The weak correlation between structured and traditional management products increases the quality of this diversification[7]. Since nobody would dispute that diversification is the key to achieve a rigorous and all- inclusive approach to their asset allocation, structured products are the means of reducing portfolio risk without altering potential gains and it may even increase those gains.

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[6] Source "Swaying investors to benefits of using structured products", Layrent Seyer, Head of Equities derivatives, Switzerland at Societe General Corporate & Investment Banking, published May 2006
[7] Same as Footnote 6

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EDHEC Risk and Asset Management Research Centre has studied the diversification effect of structured products by introducing one into a conventional "equities-bonds" asset allocation and studying how this helped optimize its risk return profile. [8]

More specifically, what EDHEC did was to define a simple structured product and simulated returns and risks for two types of asset allocation: one involving only equities and bonds and the other containing the above as well as structured product. The results were unequivocal: there are many complementary elements of the structured product and traditional assets, with a significant improvement in the risk-return profile. This was especially true when the risk measure used took particular account of extreme events. EDHEC concludes that even a modest allocation in structured products adds value to an investment portfolio.

Access to alternative assets: Structured products offer a means of accessing asset classes that would not usually be available through traditional investment vehicles. The traditional, simple investment products are been replaced by new offerings that can take commodities, hedge funds and foreign exchange markets as the underlying assets. The flexibility can extend to a mix of different asset classes, indices or baskets of individual equities.

Enhanced returns: In periods of low interest rates, receiving an enhanced yield becomes increasingly difficult. Structured products are financial instruments, whose cash flows and market values are linked to one or more underlying assets, thus offer the potential opportunity to earn a higher return than a conventional fixed deposit would give for the same period of time. The desire for higher yield leads the investors to make a risk/return trade off which reflects their market value. The total return on such products depends on the proportion of the capital protection and market participation that offers a specific risk/return profile, with the basic fundamental being that the higher the capital protection, the lower the upside participation offered on it, and vice versa.

[8] Source "Swaying investors to benefits of using structured products", Layrent Seyer, Head of Equities derivatives, Switzerland at Societe General Corporate & Investment Banking, published May 2006

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Hedging: Another attractive feature is that these products can be used to hedge unique risks faced by investors. To understand this better we can use an example: A company that owns Japanese yen is exposed to the risk of yen depreciation. TThe Federal Home Loan Bank issued a one year range accrual product that accrued interest 7%, if the JPY/USD exchange rate is above 108,50 and 0% if the JPY/USD exchange rate is at or below 108,50. So, in the occasion that the yen depreciates, the range accrual note will give interest at an above the market rate (7%) and meanwhile the company's yen holdings value will decline. Thus, this product can serve as a perfectly tailored hedge for the company's business risk profile.[9]

Market view on the underlying: Another benefit of purchasing structured notes is the opportunity to express and follow a market view. Similar to the buyer of a stock who expresses his opinion that he expects that the stock price will rise, structured products can be used in the same way. For instance, in the above mentioned example, if an investor believed that the dollar would depreciate against the yen he would have purchased this product and would be compensated for predicting correctly with a 7% rate of return. Yet, in the occasion that his view on the exchange rate proved incorrect, he would be locked into an investment which would return no interest until termination of the product.

Leverage: Some structured products offer leverage into an underlying asset or security. This means that the investor can enhance his investing power, without having to take out a separate margin loan.

Tailor made products: Structured products are very attractive for investors with defined investment periods, at the end of which they need to redeem their assets for other uses. Hence, by matching the investment period with the maturity of the product, assets are managed in optimal manner during that time.

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[9] Source "Product Summary – Structured Notes", Financial Markets Unit Supervision and Regulation, Federal Reserve Bank of Chicago, published November 1994.

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In 2005, Frank J. Fabozzi and the Editorial Board of *the Journal of Structured Finance,* through their project to determine the elusive definition of structured finance, gave us evidence of the benefits of structured products from an issuer's perspective.

More specifically, they thought that the best source of views concerning how structured finance should be defined in today's financial markets, would be the views of expert contributors in the Journal. They sent questionnaires to 53 people and received responses from 24. In their responses, there were participants that replied individually while others participated in group responses from their firms. In some of their definitions, this variety of experts emphasized the benefits provided by structured finance from an issuer's perspective, as these are summarized below:

- "Enables the financing of an unique asset class that 1) previously may have been financed only by traditional borrowing methods or 2) could not been financed at all without structured finance.
- Offers issuers flexibility in terms of maturity structure, security design and asset types, which in turn allows issuers to provide enhanced return and a customized degree of diversification commensurate with investors' appetite for risk.
- Allows the issuer to obtain better credit ratings and/ or more leverage compared to senior unsecured debt issuance.
- May reduce borrowing costs. Often captive finance companies and independent companies can obtain capital at rates better than those obtainable for the originator of the securitized assets
- May provide funding and liquidity by converting illiquid assets into cash.
- May transfer the risk of assets or liabilities to allow a bank originator to do additional business without ballooning its balance sheet
- May enable a financial institution to exploit regulatory capital arbitrage, for example through securitization of assets that offer a low return on regulatory capital
- Can be used to shelter corporations from potential operating liabilities" (Fabozzi & Choudhry, 2006).

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4.2. Basic Risks of Structured Products

After this overview on the advantages offered by structured products to an investor and an issuer, it is important to examine the main type of risks embedded in a note.

In the recent past, structured products were appealing to high net worth clients and one of the main reasons was that the majority of these investors use financial advisors who are useful in navigating the significant intricacies of most structured products. As we will see in the next chapter, the payout patterns of these securities can be very complex, requiring sophisticated financial models for valuation. More recently, there is evidence that traditional retail investors are buying structured products[10]. This is not necessarily bad, yet it is raising the interesting question about how well the disclosure-based system of securities regulation, which differs from country to country, will cope with increasingly complex products offered to retail investor (Bethel & Ferrell, 2007)

Below we summarize the main **type of risks** embedded in a note. These risks concern the majority of structured products, including the many types of structured products are not discussed in this paper. The understanding of the types of risk by the investor is very important, in order to correct evaluate whether the product's risk profile is equivalent with the risks she is capable and willing to undertake. Furthermore, comprehending the risks will also assist an institution, in determining whether is properly analyzing the risk profile of its investment in structured notes.

The first type of risk is **Market risk.** Market risk can be defined as the risk to a security's market price due to adverse moves in structured products underlying benchmark. An investor's or institutions assessment of market risk begins with the determination of current and potential future market values. The embedded option inherent in the structured notes result a great deal of uncertainty regarding future cash flows, hence structured products price volatility is generally high. The investor / institution should have access to a model

[10] For more information see "Protecting Investors who Invest in Structured Products", Bethel, J & Ferrell, A, Prepared for the Bookings/Tokyo Club Symposium, 2007

which is able to quantify the risks, forecasting the change in market price at various points in time for a given shift in underlying benchmark’s levels. Yet, as have been discussed, in most cases full principal will returned in maturity.

An additional risk is **Liquidity risk,** meaning the risk that an individual investor, or an institution, will not be able to sell or “unwind” a position in a structured note, prior to maturity, at (or very close) to its perceived market value. Due to the complex nature of structured notes, the number of firms that would be able and willing to competitively price and bid for these securities is very small. Thus, the fewer the bidders, the competition is lessened. Consequently, an investor/ institution which hope to sell prior maturity the structured note that hold may find that the only option is to sell it with a significant loss. An active secondary market is only gradually developing and usually, the note’s original issuer is the only source for bid before maturity, which is not always guaranteed.

The third type of risk is **Interest Rate risk,** which describes the risk of cash flows posed by an adjustment in market interest rates. Of course, every day individual investors and institutions make investment decisions which incorporate an opinion on future rates, hence this should not be considered as a new risk. What is unique with structured products is that these decision’s risk/ reward profile is much more pronounced. More specifically, these products often require more specific assumptions tied to very exact points of the yield curve. In other words, it in not enough to correctly forecast that interest rates will increase or decrease, but have also to be accurate on the timing and the magnitude of this rate change.

Another risk is **Creditworthiness of the issuer** of a structured note. The extent to which any initial investment is protected is subject to the quality of the issuer’s credit, meaning her ability to meet scheduled interest or initial capital payments. The investor / institution should investigate the creditworthiness of the issuer, in order to evaluate the risk that the issuer would not be able to keep his interest and principal payment obligations.

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<u>Chapter 5: Pricing of Structured Products, a Literature review</u>

As with other financial instruments, the question of valuation is of particular interest for structured products. Yet, although structured products emerged in the U.S. market back in the 1980's, comparatively little interest was paid to them in the literature. In addition, very few investigations dealing with their evaluation have been done. Below we summarize the main parameters, which, in our opinion, are responsible for this disproportion existing between the popularity of structured products and the research has been done to date concerning their pricing.

One reason is that in most cases **very complex probability and pricing models** are required to accurately evaluate and price these instruments. As mentioned earlier, most structures have embedded options, implicitly sold by the investor to the structured product's issuer, and moreover, in most cases complex payoff functions are used, which make the adoption of an appropriate pricing model that evaluates accurately these instruments difficult. Even a simple structured product such as a plain vanilla equity-linked bond requires considerable effort and knowledge to decompose it to its elements.

Furthermore, issuing institutions often embed **various types of fees** in the structured products, which reduce transparency and at the same time is difficult for a pricing model to include them in the pattern. There is a common rule of thump that says that the more complex the instruments, the higher margins the issuing institution will charge to the investor. In fact, structured products offer investment strategies that private investors may not be able to pursue due to high transaction costs and lack of knowledge. But, issuing institutions can effectively offer these products to the public, through their economies of scale. There is no doubt that the institutions want to be compensated for their work through the pricing of the structured products.

Additionally, **a secondary market** for structured products is only gradually evaluating. Usually, although there is no formal obligation to do so, the issuing institution acts as a market maker for its own products. It is to be assumed that no additional cost is generated for the

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issuer for running a secondary market. Yet, since the issuing institution is the only market maker, transparency and competition is limited, thus is under question whether the issuers are giving fair quotes on the market.

Literature Review

First research elements can be found in the 1990s, when **Chen and Kensinger (1990)** investigated Market Index Certificates of Deposits (MICD) that offer a guaranteed minimum interest rate and a variable interest rate tied to the growth of the S&P 500. Using a sample of 18 MICD in January 1988 and 25 MICD in January 1989, they compared the implied volatility of the S&P 500 options with the implied volatility of the options embedded in MICDs and revealed significant positive and negative differences between theoretical and market values. They found inconsistencies in the pricing among issuers as well as among MICDs of different maturities and different types offered by the same issuer (Wilkens et al, 2000).

Chen and Sears (1990) analyze the "S&P 500 Index Note" (SPIN) issued by Salomon Brothers, which is very similar to the MICD but exchange-traded. The SPIN is a four year, 2% coupon bond which at maturity pays its holder the principal amount and the accrued interest plus the excess of the S&P 500 Index value over the initial value of the index times a predetermined multiplier. In essence is a combination of a low coupon bond plus a long-term call option on the S&P 500 Index (Frohm, 2007). They analyzed the differences between market and theoretical prices, using ex-post, average implied and long-term implied volatilities, over three sub periods in products lifecycle spanning from September 1986 to December 1987. They found overpricing in the first sub period of approximately 5% whilst in the second and third sub periods, the product was under priced. Chen and Sears concluded that the market was going through a learning process in pricing this new and unique type of security. (Chen/Sears, 1990).

According to Grunbichler et al (2002), Chen and Chen (1995) study the valuation of one structured product without principal protection, in the secondary market, offering investors relatively enhanced returns in exchange for a cap on the underlying stock's growth. They find a persistent overvaluation amounting some 5%.

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Three studies exist for the Swiss Market. First **Wasserfallen and Schenk (1996)** study the pricing of thirteen structured products with principal protection listed on the Swiss Market (SMI) Index, between January 1991 and April 2002. The number of trading days examined span from 21 to 80 for each product. They compared the product's option components with the historical and the implied volatility of the SMI Index and concluded that the securities are sold slightly above their theoretical values. The results overall, show clearly that products tend to be overvalued at first issue, whereas they have the tendency to be undervalued in the secondary market. Finding the range of error for all instruments below 10% and the root mean square error above 3% only in two cases, they conclude the products re fairly prices.

Another study for the Swiss market is conducted by **Wohlwend et al (2001)** that analyze the initial pricing of 275 structured products without principal protection that were outstanding on August 1999. The products were issued by 15 different issuers. The study was the first of its kind to discuss the pricing of concave products. Products with a concave payoff function, in contrast with products with convex payoff function, can be seen as a position in the underlying asset in combination with a short position in a call option on the same asset. In other words, the investor buys the underlying asset at a discount but gives up a substantial part of the upside potential. On the opposite side, convex products, so called capital protected notes, guarantee a minimum terminal value at maturity but yield a certain upside potential at the same time. Such a strategy can be replicated through a long position in a risk less investment in combination with one or more call options on an underlying asset.

Based on the put-call parity for European options, concave investment strategies can be implemented in two ways. Either through a position in the underlying asset together with a short call option on the same asset or through a risk less investment in combination with a short put option. The two equivalent strategies can be characterized as follows:

$$P_{model} = Xe^{-r(T-t)} - p_t = S_t - c_t - \sum_{i=1}^{1} D_i e^{-r(t_i - t)} \qquad (5.1)$$

, Whereby

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Pmodel = Model price of structured product

X= Strike price

r= risk less rate of return

T= Maturity of structured product

t= Current point of time

pt= Price of European put option

St= Price of the underlying asset

ct= Price of European call option

Di= Dividend payment of the underlying asset (i=1,2,3…i)

ti= Date of dividend payment i

In the case of structured products paying a fixed coupon, equation is extended to

$$P_{model} = Xe^{-r(T-t)} - p_t + \sum_{j=1}^{1} CP_j e^{-r(t_j-t)} = S_t - c_t - \sum_{i=1}^{1} D_i e^{-r(t_i-t)} + \sum_{j=1}^{1} CP_j e^{-r(t_j-t)} \qquad (5.2)$$

, whereby

CPj=Coupon payment j (j=1,2,3….j)

tj= Date of coupon payment

In order to assess the appropriateness of the initial product offerings, the price at issuance, P_{market}, are compared to the values from the synthetic strategies, $P_{model,}$ as shown above. A standard Black / Scholes-model is used to derive the option prices in equations 1 and 2 respectively. To implement the option pricing formula an implied volatility measure is used which is extracted from traded options at the EUREX, the German/ Swiss option exchange. Since options traded in EUREX are of American type, meaning can be exercised anytime during the lifetime of the option, a Cox /Ross / Rubinstein (1979) model is implemented in order to derive the implied volatilities. The relative price difference in percent is hen defined as:

$$PD = \frac{P_{market} - P_{model}}{P_{model}} \qquad (5.3)$$

If this difference is negative hen investor get a better deal b buying the structured product instead of the underlying asset. If the difference is positive, then the investor could achieve the

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same payoff at lower cost if he implemented the replicating strategy in the underlying markets directly.

As authors expected, they find a statistically significant bias in favor of the issuing institutions. On average the price differences between theoretical and market values lie at 1.91% with a standard deviation of 2.39%. This difference compensates first of all issuers efforts associated with the management of the product, but it is hard to judge what proportion of this difference is caused by marginal cost and what proportion goes to the issuing institution as a net profit.

Furthermore they observe that differences on the pricing of the products vary considerably, depending on the product category and the co-lead managers that are involved. More specifically, they distinguished between products with and without fixed coupon payments. Structures with a coupon payment were substantially more mispriced than those without a coupon, since the notes with the fixed coupon are typically managed at the institution's fixed income desk and sold in a bond like manner. This perception as a bond-related investment makes investors pay a premium for these instruments.

Finally, they conclude that co-lead managers play a role in the issuing process of a new note. These co-lead managers are smaller institutions that do not manage the product on their own but issue the product in cooperation with other larger banks. They first collect quotes from various bigger institutions and eventually cooperate with the one that gave the best offer. Consequently, structured products whose issue is co-led by a third part are better priced and show a smaller dispersion of pricing errors.

In sum, they find substantial price distortions across the various segments of the market under investigation. Yet, they add that the differences between the offerings proved "statistically" but not "economically" significant, meaning the mispricing does not leave room for arbitrage opportunities. Furthermore, structured products are containing strategies that would not be accessible otherwise to simple investors and even thought these products may not be perfectly priced, they still are the best deal a small investor can get.

The third study in the Swiss market was contacted by **Grunbichler and Wohlwend (2002).** They discuss the valuation of 192 structured products without a capital guarantee in primary and secondary markets. The methodology used for this study is based on the comparison of the implied volatilities of the options contained in the products with those of comparable EUREX Index options. To get the implied volatilities from the structured products they first extract the price of the options position involved in the products.

According to the authors, a structured product without coupon payments can be duplicated by a risk less investment and a short put with the same strike and maturity as the structured product. They define the price relationship as follows:

$$SP_t^{wc}(X,T) = Xe^{-r(T-t)} - p_t(X,T) \tag{5.4}$$

, whereby

SP_t^{wc} *=Price of a structured product without coupon payments at time t, with strike price X and expiration date T*

X= Exercise price

r= risk less rate of return (continuously compounded)

t= Current time

T= Expiration date

Pt(X,T)= Price of European put option with strike price X and expiration date T at time t

They solved equation (4) for the put price and then they exacted the implied volatility with the model Black / Scholes (1973) adjusted for discrete dividend payments[11]. In a similar way, a structured product with coupon payments can be duplicated. In that case, the price of the implicit European put option is expressed as follows:

$$p_t = Xe^{-r(T-t)} - SP_t^c + \sum_j^J CP_j e^{-r(t_j - t)} \tag{5.5}$$

, whereby

[11] See Hall (2000)

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$SP_t^c(X,T)$= *Price of a structured product with coupon payments at time t, with strike X and expiration date T*

CPj= Coupon payments j (1,2,3….j)

tj= Date of the coupon payment j

Beside the implied volatilities of the structured products they also extract the implied volatilities from the EUREX options. Here as well, a Cox / Ross / Rubinstein (1979) model is implemented to generate the implied volatilities, since EUREX options are Americans style.

Using these volatilities, authors calculate the difference in implied volatilities for each product pair (structured product plus its assigned EUREX option) and for each point in time, according to the following expression:

$$VD_{i,t} = s_{SPi,t} - s_{EUREXi,t} \tag{5.6}$$

, whereby

$VD_{i,t}$ = *Volatility difference of product pair i in time t*

$s_{SPi,t}$ = *Implied volatility of structured product i in time t*

$s_{EUREXi,t}$ = *Implied volatility of EUREX option i in time t*

The authors find misevaluation of 4.25% in the primary market and 1.65% in the secondary market to the investor's disadvantage. They also observe that misevaluations decline significantly during the lifetime of the product. This is because of two reasons: Firstly, in the primary market, the full direct transaction costs were not included in the study for the sake of practicability. Secondly, because the differences in time to maturity between the structured products and the assigned EUREX options mean that investors would not be able to arrive at the same payoff pattern as with structured products. They also find that the analysis of the products from different lead managers shows that valuation differs markedly for some of them in both primary and secondary market. Similarly, authors observe large and significant differences emerged during the investigation of product categories (with or without coupon payments products).

For the German market **Wilkens et all (2003)** examine the pricing of 906 structured products linked to German stock indices DAX and NEMAX at a time frame of 22 trading days. Author's research is based on a special class of structured financial products, namely reverse convertibles and discount certificates. ***Reverse convertibles*** have a fixed nominal value as well as a coupon that typically exceeds the market interest rate for corresponding bonds. At maturity the investor can choose between redeeming the bond's nominal value or receive a predetermined number of shares. ***Discount certificates***, a slightly modifies version of reverse convertibles, offer at maturity the shares at a discount from the current market value, unless the total value is below a maximum repayment amount. In this case, certificate pays this amount in cash. With the repayment mechanism being identical to the one for reverse convertibles, with the exception of coupon payments, these products are sometime referred to as "zero-coupon reverse convertibles".

For this study, authors take daily closing quotes of roughly 170 reverse convertibles and 740 discount certificates and compare them to theoretical values based on duplication strategies using call options traded in the EUREX. They investigate the average price differences depending on the product type, issuer and underlying asset.

As already analyzed in the studies mentioned previously, *duplication* is the reconstruction of the product payment profiles by its several single components. For the theoretical option prices they use the Black / Scholes (1979) option pricing model while for the risk free elements, that is reverse convertibles or discount certificates, they employed the formula of a coupon-bearing bond, with present value GB_t. On valuation day t, assuming a flat term structure of interest rates, a coupon-bearing bond has a value of

$$CB_t = NVe^{-rdt} + \sum_{j=1}^{m} I_j e^{-rd(t_j^I - t)} \tag{5.7}$$

, whereby

CB_t *= Coupon-bearing bond value*

NV *= Nominal value of structured product*

rd= Interest rate adjusted for the default risk of bonds, continuously compounded

Ij= Interest coupons, j=1,2,3….m

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t_j^I = *Date of jth interest coupon payments*

Consequently, the theoretical product value, SP_t, at time $t \leq T$ is given by

$$SP_t = CB_t - s \times p_t \tag{5.8}$$

, whereby
s= Number of derivatives shares

Wilkens et al (2003) reported a significant pricing bias in favor of the issuing institutions. The authors also analyze the driving factors of the issuer's pricing policies. They found strong evidence for their hypothesis that issuers orient their pricing towards the lifetime of the product and the risk of redemption of shares (Frohm, 2007). They conclude that average mispricing decreases with the time to maturity and increases with moneyness of the implicit option (Wilkens et all, 2003).

Finally, the last published study is **Frohm's (2007)** on Index-Linked notes issued by in Sweden in 2005. The author investigates the pricing of 22 index-linked notes during their full life cycles, from 12 January 2005 to 17 January 2007. The selected products constitute 40% of the structured products issued by Swedbank in 2005, which at the time of the study is the second largest issuer of structured products to private investors in Sweden.

In order to calculate price differences, the author compares quoted prices on secondary markets with theoretical prices, calculated through duplication strategies that use exchange traded options, a methodology that was already used in previous mentioned studies.

The results show that quoted prices deviate very little from their theoretical values in secondary markets. Additionally, the price deviations are surprisingly low in an international comparison. Some indications have been found that the market maker is able to influence prices on secondary market by orienting the pricing towards the relative life cycle and the moneyness of the structured products. These results confirm Wilkens et al econometric model and are consistent with empirical investigations in Germany and Switzerland.

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Chapter 6: Motivation on Structured Products, an Empirical study

Previously, when we categorized structured products, one of the criteria was to divide them based on the underlying asset their performance is linked to. Then, we recognized four major subcategories:

1. Interest Rate-Linked Notes
2. Equity-Linked Notes
3. Foreign Exchange-Linked Notes
4. Commodity-Linked Notes

In this chapter we will examine separately three structured products for each category, which were issued in the Eurozone between January 2003 and March 2007. First we will define their specifications and payoff functions and then we will analyze the motivation on these products.

Thereafter, we will observe structured products' performances or the so far performances in case a product is still running. Then, we will look into each product's underlying asset time series and calculate their summary statistics, in order to understand weather an investor can make safe projections based on the past performance of the underlying asset a structured product is build upon.

Finally, we will make some comments and conclusions on the motivation on the four categories of structured products we have defined and also on any interrelation among underlying assets' time series and structured products performances.

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6.1. Interest Rate-Linked Products

6.1.1 Specifications

I. <u>Interest Rate Range Accrual Callable Note, Issuer Societe General</u>

The abovementioned product has the following basic terms and conditions:

<table>
<tr><td>Currency</td><td colspan="2">USD</td></tr>
<tr><td>Protection</td><td colspan="2">Capital Guaranteed</td></tr>
<tr><td>Minimum amount</td><td colspan="2">USD 10,000</td></tr>
<tr><td>Issue Date</td><td colspan="2">24/12/2004</td></tr>
<tr><td>Maturity Date</td><td colspan="2">24/12/2010</td></tr>
<tr><td>Callable</td><td colspan="2">24/03/2005, and every quarter there after at 100%, that is the issuer has the right to early redeem this product from that point and thereafter and until maturity date</td></tr>
<tr><td>Redemption price</td><td colspan="2">100%</td></tr>
<tr><td>Coupon</td><td colspan="2">Quarterly</td></tr>
<tr><td>Underlying asset</td><td colspan="2">6M USD Libor</td></tr>
<tr><td>Payoff function</td><td colspan="2">$8\%\times(N/N_{total})$, Whereby

N= Number of days that the Reference Index remains within the range (limits included), for each interest period
Ntotal= Total number of days for each Interest Period</td></tr>
<tr><td>Ranges</td><td>1st to 4th quarter
5th to 8th quarter
9th to 12th quarter
13th to 16th quarter
17th to 20th quarter
21st to 24th quarter</td><td>0,00% – 3,75%,
0,00% – 4,25%
0,00% – 4,75%
0,00% - 5,25%
0,00% - 5,75%
0,00% - 6,25%</td></tr>
</table>

More specifically, this is a six-year 100% principal guaranteed range accrual structured product that started on 24/12/2004 and terminates on 24/12/2010, unless an early redemption occurs. The coupon is paid quarterly and the payoff formula is based on the variations of the 6M USD Libor. More specifically, the investor will receive an 8% per annum for every day of the coupon period that the 6M USD Libor fixes within the predetermined ranges. For example, if during year 2008, that is between the 13th and 16th quarter, the 6M USD Libor fixes below 5.25%, then the investor will receive a the maximum coupon, 8% per annum. But if, on year 2009, that is between 17th and 20th quarter, the 6M USD Libor fixes below 5.75% only during

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the 190 out of 252 trading days of the year, then the investor will receive 8%* (190/252) per annum.

II. Interest Rate Range Accrual Callable Note , Issuer Banco Commercial Portuguese

The abovementioned product has following terms and conditions:

Currency	EURO	
Protection	Capital Guaranteed	
Minimum amount	EURO 10,000	
Issue Date	12/05/2004	
Maturity Date	12/05/2009	
Callable	12/11/2004, and every semester there after at 100%, that is the issuer has the right to early redeem this product and return to the investor his initial invested capital	
Redemption price	100%	
Coupon	Semi/annual	
Underlying asset	6M Euribor	
Payoff function	$5{,}75\% \times \left(N / N_{total} \right)$, *whereby* ***N****= Number of days that the Reference Index remains within the range (limits included), for each interest period* ***Ntotal****= Total number of days for each Interest Period*	
Ranges	1 year 2 year 3 year 4 year 5 year	0,00% – 3,05%, 0,00% – 3,55% 0,00% – 4,05% 0,00% - 4,55% 0,00% - 5,05%

Particularly, this product is a five-year 100% capital guaranteed range accrual structured product, which started on 12/05/2004 and terminates on 12/05/2009, unless it will be called earlier. The underlying asset is 6M Euribor, the coupon is paid semi annually depending on whether official closing prices of the underlying asset will satisfy defined ranges. For example, if on year 2 the 6M Euribor was above 3.55%, than the investor would receive zero return for that period. If on year 3 the underlying asset is below 4.95% during the 25 days out of 252 trading days of the year, then the investor would receive 5.75%*(25/252) per annum.

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III. <u>Range accrual note , Issuer Rabobank</u>

The abovementioned product has following terms and conditions:

Currency	EURO
Protection	Capital Guaranteed
Minimum amount	USD 1,000
Issue Date	14/12/2006
Maturity Date	14/12/2007
Redemption price	100%
Coupon	Semi/annual
Underlying asset	6M Euribor
Payoff function	$4,25\% \times (N / N_{total})$, *whereby* ***N**= Number of days that the Reference Index remains within the range (limits included), for each interest period* ***Ntotal**= Total number of days for each Interest Period*
Ranges	3.60% - 4.10%

This is a one-year 100% principal guaranteed range accrual structured note, which started on 14/12/2006 and matures on 14/12/2007. The coupon is paid twice a year and the underlying asset is the 6M Euribor. Furthermore, since this is a range accrual product, investor can receive a maximum 4,25% return per annum, if the 6M Euribor remain within the ranges of the product (3,60% - 4,10%). For example, if during the tenor of the product the 6M Euribor is between the ranges, the investor will receive the maximum coupon, 4.25%. But if the underlying asset exceeds the barriers, then she will receive a proportion of the coupon, depending on the days it remained inside the range.

6.1.2 Motivation on Interest rate-Linked structured products

The most important motive of these structured products is the **100% principal protection** at maturity, which gives the buyer the advantage to participate without putting the initial capital at risk, but only by keeping it until maturity. This is an serious advantage compared to other financial instruments, plain vanilla options for example, in which the initial invested amount is not protected from events that can provoke negative price fluctuations of the underlying asset, and consequently of the embedded option.

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Moreover, the **minimum amounts required** to invest in these structured products are low, varying from 1,000 -10,000 (Usd or Euro). This characteristic makes the products attractive to sophisticated investors as well as to retail investors. Firstly, because a sophisticated investor can put only a small proportion of his capital to each one of these products, so as to diversify his portfolio or further, to obtain a certain hedging strategy. Secondly, the fact that these minimum requirements are sustainable low, makes these complex and enhanced products, in terms of structure and return, accessible to retail investors.

Furthermore, a strong motive on these structured products is the **enhanced returns** the issuers are engaged to give, as long as the underlying assets remain within the barriers. The coupon these products are committed to return are higher compared with the return a time deposit or a plain vanilla bond would give at the same period, so for an investor that has access they seem pretty attractive.

Another motive is that interest rate-linked notes offer value from a portfolio **diversification** perspective. Analysis has shown that all the optimal portfolios contain a mixture of plain vanilla cash products and interest rate-linked notes.[12]Other examples, on how these products offer diversification in a portfolio, are CMS-linked notes which offer stability in a volatile short-term interest rate environment and inverse Floating range notes (FRN) that act as a hedge to the volatility of reinvested income in a bond portfolio.

In addition, another motive is that an investor can embed his **speculation on interest rates**, European or American, and benefit from their movements. Obviously, investor's perception on the underlying assets of the products mentioned before is that interest rates will increase but also will remain within the determined ranges. Hence, he has a bullish view on interest rates, meaning he expects them to increase, for several reasons such as continuing economic growth or/ and low inflation. Consequently, by having a view on interest rates, an investor can purchase each of these Interest rate-linked products today and benefit from the higher coupon they offer.

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[12] For more information see "Structured notes in a portfolio context", Alex Haidas, Funded Solutions JP Morgan, October 2003.

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Finally, one strong motive, that mostly concerns product III we analyzed previously (a one year capital guaranteed structured product), is the **short tenor** of the products. In general, products with short tenor are more attractive in the sense that it is easier to make a forecast for a short period, that is for 1 to 2 years, than for a longer, for example for 15 or 20 years. The structured products analyzed in this section, have tenors that vary form one to six years. Obviously, the product III is more advantageous in terms of tenor, compared to the other two Interest rate-linked products.

6.1.3 Performance of the Interest rate-Linked structured products

We calculated the performance of the three products based on their payoff functions. For the Products I and II, which are still running we calculated the so far performance while for structured Product III we calculated the total performance since the product has already terminated[13]

Product I and III had really bad performances. The first one has returned only 4.10% per annum in three years, whilst its underlying asset has exceeded the ranges for a very long time, whilst Product III terminated giving the investor a zero return. On the other hand, Product II has given a good so far performance, offering to the investor the total coupon according to the payoff function.

Looking into summary statistics of the underling assets in Table 1[14], we observe that the Sharpe ratio for Products I and II is negative and far from the minimum required, while for the Product III is pretty satisfactory. In other words, a product with high Sharpe ratio (Product III) underperformed a product with negative ratio (Product II), which is quite unexpected. However, as far as we can see in Table 1, time series are not normally distributed, with fat tails and Skewness in the distribution. Additionally, the Standard Deviation is not far from its mean for all three products, yet as mentioned before the time series distribution is not normal.

[13] See APPENDIX 2, Tables 2, 3 & 4
[14] See APPENDIX 2, Table 1

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Finally, the 100 days Historical Volatility[15] for all three products is not very high, but interest rates fluctuations are by nature not very wide, either, at least for periods when unpredictable event does not occur in the global economy.

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[15] See APPENDIX 2, Figures 2, 4 & 6

6.2. Equity-Linked Products

6.2.1 Specifications

I. <u>Equity 3 Year Capital Guaranteed - Absolute Performance Basket, Issuer BCP</u>

The abovementioned product has following terms and conditions:

Currency	EURO
Protection	Capital Guaranteed
Minimum amount	EURO 1,000
Issue Date	14/12/2006
Maturity Date	14/12/2009
Coupon	1 payment during the lifetime of the product
Underlying asset	Basket equally weighted, composed by three stock Indices: **Euro Stoxx50, S&P 500, Nikkei 225**
Payoff function	$RA = IA \times \left[1 + Min\left(47\% \times \lvert Performance \rvert \,;\, 27\%\right)\right]$, *whereby* *RA= Return amount* and *IA = Initial amount*
Performance	$\left(\frac{1}{3} \times \sum_{i=1}^{3} \left(\frac{Index^{i}_{final}}{Index^{i}_{initial}} - 1\right)\right)$, *whereby* $Index^{i}_{initial}$ *= The official closing level of index i in the Basket on Issue Date* $Index^{i}_{final}$ *= The official closing level of index i in the Basket on Maturity Date*

More specifically, this is a three-year principal guaranteed structured product, which started on 14/12/2006 and will terminate on 14/12/2009. There is just one payment that will occur at the end of the product while the underlying asset is an equally weighted basket, comprised by three major indices, the Euro Stoxx50, S&P 500 and Nikkei 225. According to the payoff function, on the termination date product will give a return equal to the 47% of the average performance of the basket. There is a cap in this product, meaning there is a maximum coupon, which in this case is 27% for the three years. Basket performance is calculated by adding up three indices' performance realized during the product's lifetime, and more specifically by subtracting official closing level of each index on settlement date from the official closing level of respective index on maturity date.

II. 3-years Capital Guaranteed Equity linked Auto-callable, Worst Off Note , Issuer Banco Commercial Portuguese

The abovementioned product has following terms and conditions:

Currency	EURO
Protection	100% Capital Guaranteed
Minimum amount	EURO 1,000
Issue Date	11/12/2006
Maturity Date	11/12/2009
Callable	11/12/2007 and 11/12/2008 if Basket final closing price is bigger than Basket initial price
Underlying asset	Basket equally weighted, composed by three equities: **Nestle SA, Novartis AC, RWE AG**
Payoff function	If on 11/12/2007 *Basket* $P_{final} > P_{initial}$ then $IA \times (1+10\%)$ If on 11/12/2008 *Basket* $P_{final} > P_{initial}$ then $IA \times (1+20\%)$ If on 11/12/2009 *Basket* $P_{final} > P_{initial}$ then $IA \times (1+30\%)$, *whereby* *IA= Initial Amount* $Basket\,\mathrm{Pr}\,ice_{initial}$ = *The official closing level of Basket of equities on Issue Date* $Basket\,\mathrm{Pr}\,ice_{final}$ = *The official closing level of Basket of equities on Maturity / Call Date*

More explanatory, this is a three-year 100% capital guaranteed product that started on 11/12/2006 and matures on 11/12/2009. This product is auto callable, which means could terminate in the occasion a pre-specified condition occurs, otherwise will continue to run until maturity date. More specifically, in this product's case, if the closing price of the basket on callable dates (11/12/2007 & 11/12/2008) exceeds the initial price of the basket, then the product will be called, investor will receive the promised yield and the product will terminate. This yield varies, based on the formula of the product. For example, if the closing price of the basket on 11/12/2007 is bigger then the basket's initial price, then the product will be called and the investor will receive a 10% per annum. If not, then investor will not receive a yield and the product will continue to run until next callable date, where we will observe the closing price of the basket again. If the closing price is bigger compared to the initial price, the product will be called and the investor ill receive a total 20% for the two years she kept the product, etc.

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III. 12 Month Adagio on Euro Stoxx50, Issuer Deutsche Bank

The abovementioned product has following terms and conditions:

Currency	EURO
Protection	Capital Guaranteed
Minimum amount	EURO 1,000
Issue Date	01/01/2005
Maturity Date	01/01/2006
Coupon payment	Annual
Coupon	12M Euribor + 50 bps
Underlying asset	Euro Stoxx50
Observation	Daily, at closing time
Range	Lower barrier =2227,52 Higher barrier=3712,53 Fixed at inception as a percentage above and below the spot level
Payoff function	If Index Closing price on maturity is between the Range, then $IA \times 100\% + (12MEuribor + 50bps)$ If Index Closing price exceeds the Range, then $IA \times 100\%$ *, whereby IA= Initial Amount*

This is a one-year principal guaranteed structured product, which started on 01/01/2005 and terminated on 01/01/2006. The minimum amount an investor can purchase is €1000; the coupon is paid once at maturity and is equal to the12M Euribor, as this was determined on termination date, plus 50 basis points. For example, if on 01/01/2006 the 12M Euribor closing price was 4.12%, the coupon to be paid would be 4.62%. The underlying asset is Euro Stoxx50 Index and the payoff function is based on the condition that all daily closing prices of the Index during the lifetime of the product are varying between +/- 25% of the Index price, as this was observed on initiation date. That is to say, if on 01/01/2005 the Euro Stoxx50 price was at 3200 points, the daily closing prices during the lifetime of the product should not exceed 2400 – 4000 levels.

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6.2.2 Motivation on Equity-Linked Structured Products

For all three structured products of this subcategory, the motivation for the investor is primarily the **principal guaranteed** term, which allows the investor to participate in the stock market without the possibility to lose his initial capital to maturity. In addition, the capital guaranteed term in an equity-linked structured product makes it even more attractive when compared with structured products linked to different underlying assets, for example interest rates, due to the fact that the equities or indices as an underlying asset have higher volatility and thus are more risky instruments.

Moreover the **rate of return is enhanced** compared with the return other financial instruments, for example a plain vanilla bond or a time deposit would give. Probably, if one invested on equities or indices directly, would have considerably higher returns than the ones offered by the structured products. Yet, the risk return relationship is better in an equity-linked structured product with capital protection at maturity than investing in the underlying asset directly.

Further, another motive for the investor, which concerns the first two structured products analyzed previously, is that the underlying asset is a basket of equities/indices, in other words is similar to a **diversified** portfolio composed by equity-linked instruments. This characteristic decreases the risk of the structured product, since the performance depends on more than one equity / index. Additionally, as far as it concerns the products containing indices, is difficult for an investor to include in her portfolio all the stocks of an index in order to simulate its performance. Finally, the fact that these equities/indices are from different sectors / markets, diversifies further the risk of the basket, hence if one sector/ market doesn't outperform, the losses could be covered by the other two.

Another motive concerning products I and III, is the fact that the investor will receive a rate of return, on an increase or a decrease scenario. Particularly, its **strategy is not directional**, meaning that whether the underlying assets increase or decline, investor will receive a coupon, as long as the price fluctuations do not exceed the ranges of the structure. Thus, even if global stock markets are declining, the structured product's performance is not affected. Obviously, the only bet that the investor has to play is that the underlying assets will change within the tenor of the product.

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On the other hand, the motivation on the second equity-linked product, which comprises of a basket of equities, is that the specific companies will grow. Consequently their prices will rise, giving the investor an enhanced return.

Finally, the **short tenor** of the product and the low required **minimum amount** to participate in the products, are very strong motives, which concern product III. Firstly because the investor has to make projections only for one year, which is less risky compared to longer tenor structured products. Further, he can participate in this product with a small amount investing his remaining capital to other asset classes.

6.2.4 Performance of the Equity-Linked structured products

We also calculated the performance of the Equity-linked structured products of our sample. Product III was successful, since it returned the predetermined coupon and terminated. Products I and II, haven't given a return yet, due to their especial payoff functions which return the interest on maturity / termination, but their so far performance indicates that the investor will receive the promised enhanced yields[16].

Looking into the summary statistics[17], we noticed that Sharpe ratio is higher in Product III, while is under the minimum required for all three products. The Standard Deviation is not far from its Mean for all three products, which consist a good evidence for the structured product's performance, taking into account the fact that for two of the products the strategy is not directional. Also all three products have flat distributions, as this is indicated from their Kurtosis.

Moreover we calculated a 100 days Historical Volatility for Products I and II and a 30 days Historical Volatility for Product III[18]. We observe that even though the historical volatility is pretty high for some of the indices / equities, yet, by including them into a basket with other equities, more defensive ones, the results are normalized.

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[16] See APPENDIX 2, Tables 5 & 6
[17] See APPENDIX 2, Table 1
[18] See APPENDIX 2, Figures 11, 14 & 16

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6.3. Foreign Exchange-Linked Products

6.3.1 Specifications

I. Range Accrual GROI on EUR /USD, Issuer UBS

The abovementioned product has following terms and conditions:

Currency	USD
Protection	100% Capital Guaranteed
Issue Date	03/01/2007
Maturity Date	28/12/2007
Underlying asset	Fixing EUR / USD exchange rate
Coupon	8,05% per annum
Spot basis	1,322 USD per 1 EURO
Lower strike	1,27 USD
Higher strike	1,34 USD
Total number of fixing	252
Fixing dates	Daily
Payoff function	If 1.27<Fixing EUR/USD<1.34, then investor receives $IA \times 8,05\%$ If Fixing EUR/USD<1.27 or Fixing EUR/USD>1.34 then $IA \times [100\% + 362/360 \times (0\% + N/252 \times (8,05\% - 0\%))]$, *whereby* *N= Number of Days that the Fixing EUR/USD exchange rate is within the ranges.*

More explicitly, this is a one-year principal guaranteed range accrual structured product, which started on 03/01/2007 and is going to expire on 28/12/2007. The coupon is paid once on maturity date and the underlying asset is the Fixing EUR/USD exchange rate. According to the payoff function, the investor has the chance to earn 8,05% for the number of Fixing Dates the EUR/USD exchange rate trades within the predefined range (excluding strike prices). For the number of Fixing Dates that the FX rate trades at the strike prices or outside the range, the product will not accrue interest.

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II. Range Accrual Knock-out GROI on EUR /USD, Issuer UBS

The abovementioned product has following terms and conditions:

Currency	USD
Protection	100% Capital Guaranteed
Issue Date	04/01/2007
Maturity Date	03/07/2007
Underlying asset	Fixing EUR / USD exchange rate
Coupon	10,0441% per annum
Spot basis	1,3234 USD per 1 EURO
Lower strike	1,2650 USD
Higher strike	1,35 USD
Total number of fixing	126
Fixing dates	Daily
Payoff function	If 1.2650<Fixing EUR/USD<1.35, then investor receives $IA \times 10,0441\%$ If Fixing EUR/USD<1.2650 or Fixing EUR/USD>1.35 then, $IA \times [100\% + 181/360 \times (0\% + N/126 \times (10.0441\% - 0\%))]$, *whereby* *N= Number of Days that the Fixing EUR/USD exchange rate is within the ranges.*

Specifically, this is a six-month capital guaranteed structured product on EUR / USD exchange rate. In addition, it is a range accrual product that its only payment will occur on the maturity date. The special feature of this product is the knock out term in case a specific even occurs. Particularly, this note accrues interest for the days the EUR / USD exchange rate is within the lower and higher strikes but in the occasion the fixing EUR / USD FX rate exceeds these ranges, the product will give the investor the so far obtained return and the product will stop to accrue interest up until maturity date, when the product will terminate.

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III. Range Accrual GROI on EUR /USD, Issuer UBS

The abovementioned product has following terms and conditions:

Currency	USD
Protection	100% Capital Guaranteed
Issue Date	05/01/2007
Maturity Date	03/04/2007
Underlying asset	Fixing EUR / USD exchange rate
Coupon	13,0342% per annum
Spot basis	1,3262 USD per 1 EURO
Lower strike	1,2630 USD
Higher strike	1,35 USD
Total number of fixing	64
Fixing dates	Daily
Payoff function	If 1.263<Fixing EUR/USD<1.35, then investor receives $IA \times 13,0342\%$ If Fixing EUR/USD<1.263 or Fixing EUR/USD>1.35 then, $IA \times \left[100\% + 90/360 \times (0\% + N/64 \times (13.0342\% - 0\%))\right]$, *whereby* *N= Number of Days that the Fixing EUR/USD exchange rate is within the ranges.*

Particularly, this is a three-month 100% capital guaranteed range accrual FX-linked structured product that pays the coupon at maturity. The payoff function is linked to the variations of the EUR / USD exchange rate. The investor will receive this enhanced yield for the days during the lifetime of the product where the fixing EUR / USD exchange rate is within the predetermined barriers. In the occasion the exchange rate exceeds the barriers, then for these fixing days the investor will not receive a return.

6.3.2 Motivation on Foreign Exchange-Linked Structured Products

A very important motive on the FX-linked products is the **100% capital guaranteed** term, which enables the investor to purchase an instrument based on a foreign exchange rate without the risk to lose part of his initial capital, only by holding the product to maturity. Here, as well as with Equity-linked structured products, this feature is of great importance, since the underlying asset is characterized by high volatility. Hence, a projection can easier prove

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incorrect and cause capital losses to the investor. Yet, the FX-linked structured products mentioned above, allow the investor to bet on these underlying assets without this risk.

Secondly, these products offer **higher earnings potentials** than time deposit investments and give the investor the possibility to profit from a range bound foreign exchange rate until expiration date. For every fixing of the underlying asset within the range, investor will receive this yield amount.

Third, a motivation to purchase these products could be **hedging strategies** that the investor wishes to apply in his portfolio of assets. For example, if a U.S. company owns euros, is exposed to the risk of euro depreciation. All the above products can used to hedge this risk, since, in the occasion the euro depreciates against the U.S. dollar, the range accrual note will return to the company an above the market rate and at the same time the company's, euro denominated holding's value will decline.

Moreover, the **short tenor** of these products is a motive for two reasons. One is that the investor will have to make projections on the underlying asset only for a short period, which makes it more possible to forecast correct and receive the enhanced coupon. The other is that, even if investor's forecasts prove incorrect, the initial capital would only be locked in that product for a three or a six-month period, up until maturity when she can receive back his initial capital.

Another motive on these products is that the payoff functions are structured with a **bearish view** regarding the foreign exchange rate variations. More specifically, the ranges of lower and higher strikes from the spot basis are not equal, meaning that the products give more probabilities to the exchange rate to decrease further instead of increasing. So, for an investor that has a bearish view on this FX-rate, these products seem quite attractive. This feature is sustainable, since allows an investor that has a market view on exchange rates to bet on FX-linked products that adopt the same market expectations.

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6.3.3 Performance of the Foreign Exchange-Linked Structured Products

In this section we calculated the performance of the FX-linked structured products of our sample[19]. All products have returned interest to the investor. Yet, Product III outperformed the other two products since returned the predetermined coupon and then terminated. Product I is still running and has given so far a satisfactory return, while Product II gave to the investor the 50% of the total coupon.

Looking into EUR/USD exchange rate summary statistics for the defined period, we observed that the product that had the better performance (Product III) has the lowest Sharpe ratio[20]. Yet, the Standard Deviation from the Mean is lower in Product III compared with the other two products. The underlying asset's time series distribution is flat for all three products while data is not very symmetric, taking into account the Skewness. We also calculated 30 days Historical Volatility of the EUR/USD exchange rate time series[21]. We noticed that volatility is higher on Product I, which matures in one year, compared to Product III that matures in a three-month period.

[19] See APPENDIX 2, Tables 7, 8 & 9
[20] See APPENDIX, Table 1
[21] See APPENDIX 2, Figures 18, 20 & 21

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6.4. Commodity-Linked Products

6.4.1 Specifications

I. <u>Commodity-linked note Auto redeemed, Issuer Banco Commercial Portuguese</u>

The abovementioned product has following terms and conditions:

Currency	EURO	
Protection	100% Capital Guaranteed	
Issue Date	28/03/2006	
Maturity Date	28/03/2009	
Callable	On 28/03/2007 and 28/03/2008, if condition for coupon payment occurs	
Payment	Annual	
Coupon	Year 1 Year 2 Year 3	8,5% 17% 25,5%
Underlying asset	Basket equally weighted composed from three commodities: Copper, Aluminum, WTI crude oil	
Fixing dates	Daily	
Payoff function	If $Basket\ P_{final} > Basket\ P_{initial} \times 95\%$ then $IA \times coupon$ Otherwise 0%, *whereby* $Basket\,\mathrm{Pr}\,ice_{initial}$ *= The official closing level of Basket of commodities on Issue Date* $Basket\,\mathrm{Pr}\,ice_{final}$ *= The official closing level of Basket of commodities on Maturity Date*	

More explanatory, this is a three-year capital guaranteed product, which started on 28/03/2006 and is going to mature on 28/03/2009, unless a callable event occurs and terminates earlier. The coupon is paid once the product is terminated, either on maturity date or on some callable date. The underlying asset is an equally weighted basket comprised by three commodities: Copper, Aluminum and WTI. According to the payoff function, if on any observation date, the official closing level of the basket is higher than the 95% of the official closing level of the basket on issue date, then the product pays the predetermined coupon and terminates. The price of the basket on any observation date is calculated by adding the official closing prices of each commodity and dividing this sum by three. For example if on 28/03/2007, the official closing

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level of the basket is higher than the official closing level on 28/03/2006, the investor will receive 8,5% per annum and the product will terminate.

II. <u>3year Podiumnote linked to WTI, Issuer Calyon – Credit Agricole Investment Group</u>

The abovementioned product has following terms and conditions:

Currency	EURO
Protection	100% Capital Guaranteed
Issue Date	02/01/2003
Maturity Date	01/01/2006
Minimum amount	EURO 1,000
Payment	Semi/ Annual
Coupon	7% per annum
Underlying asset	WTI crude oil
Payoff function	If WTI Pfinal>WTI Pinitial$\times$110% then $IA \times coupon$ Otherwise 0%, *whereby* $\Pr ice_{initial}$ = *The official closing price of WTI on Issue Date* $\Pr ice_{final}$ = *The official closing price of WTI on Maturity Date*

This is a three-year capital guaranteed commodity-linked structured product, which started on 02/01/2003 and matured on 01/01/2006. The coupon is semi-annual, that is there occur two payments within a year. The underlying asset is the WTI crude oil. If on any observation date the WTI official closing price is higher than the 110% of the WTI official closing price when the product was first issued, then the product offers a return 7% per annum. In the opposite occasion, investor receives zero return and the product continues to run.

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III. 4year Auto call note linked to WTI, Issuer Calyon – Credit Agricole Investment Group

The abovementioned product has following terms and conditions:

Currency	EURO	
Protection	100% Capital Guaranteed	
Issue Date	03/01/2005	
Maturity Date	03/01/2009	
Callable	On 03/01/2006 and every year thereafter, if the condition for coupon payment, as described by the payoff function, occurs.	
Minimum amount	EURO 1,000	
Payment	Annual	
Coupon	Year 1 Year 2 Year 3 Year 4	6% 12% 18% 24%
Underlying asset	WTI crude oil	
Payoff function	If WTI Pfinal>115%×WTI Pinitial then $IA \times coupon$ Otherwise 0%, *whereby* $Price_{initial}$ = *The official closing price of WTI on Issue Date* $Price_{final}$ = *The official closing price of WTI on Maturity Date*	

More specifically, this is a four-year capital guaranteed multi step commodity-linked structured product. The coupon is paid semi annually and varies depending on the coupon period we observe. The underlying asset is the WTI crude oil and according to the payoff function the product will give to the investor the predetermined coupon if on every observation date, the official closing price of the commodity is higher than the 115% of the WTI initial closing price when the product was first issued. Otherwise, the product will not accrue any interest for the observation date that the condition was not satisfied and the investor will lose the return for that year.

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6.4.2 Motivation on Commodity-Linked Structured Products

The most important motive for an investor on the commodity-linked structured products of our sample is the **100% capital protection** at maturity. Here as well, an investor can participate in a volatile market such as commodities and at the same time assure that the maximum loss he could suffer is the enhanced yield a structured products offers in a good case scenario.

Secondly, for all three structured products, there is an embedded **view on the underlying asset market**, which is expressed by their payoff functions. More particularly, especially for the last two structured products, the bullish view of these products is more than obvious. Hence, for the investor that believes on the rise of their underlying asset, in these cases the WTI crude oil, during the period of the note, these products seem pretty attractive.

Additionally, even if an investor's forecast for these underlyings is bearish, the instruments can be used as **hedging vehicles**. Particularly, in the case of the second product that we analyzed, an investor that is long on put options on WTI crude oil can hedge this risk by purchasing the specific structured product

Moreover, the **enhanced yields** these products offer, in combination with the principal protection term, bearing in mind the volatility of this particular market, makes them very popular to investors. If one observes the time series of the WTI crude oil, would see that its price increases more than the 6% or 7% per annum, which is offered by the structured products of our sample. Yet, these returns are still more enhanced than the ones offered by plain vanilla bonds with good rating or time deposits.

Furthermore, we observe that for all three products, the **tenor of the products** varies from three to four years. Bearing in mind the time series of the underlying assets of these structured products, we understand that commodities' prices have the tendency to increase over time but at the same time there are characterized by substantial short-term price fluctuations. Thus, the specific tenor of these products, allows their prices to increase and simultaneously protects the investor from daily price fluctuations.

Last, a motive is the opportunity to participate in the commodity market. It is quite difficult for the non-sophisticated investor to enter this market, since this is mostly happening through

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options and futures on commodities. Since large amounts are required as collateral in order to participate in the derivative's market, commodity-linked structured products seem a very good alternative for the retail investor, if not the only.

6.4.3 Performance of Commodity-Linked Structured Products

Finally we calculated the performance of the Commodity-linked structured products[22]. All products proved successful. Product I returned an 8.5% interest and terminated, Product II gave the investor a 4.67% per annum, while for Product III investors received 6% at the end of the first year of the product and then the product was called.

We looked into underlying assets' summary statistics and we observed that the Sharpe ratio on Product I is the minimum required, while on Product II and III was less than 1[23]. Standard Deviation from the Mean is quite large for Product I but taking into account that the Product's formula is not directional and moreover that the underlying asset is a basket of commodities, these are positive indications for the structured products' performance. In Products II and III the Standard Deviation is quite low. Finally we estimated 100 days Historical Volatility[24] and noticed that is very high, as expected due to the nature of the underlying assets.

[22] See APPENDIX 2, Tables 10, 11 & 12
[23] See APPENDIX 2, Table 1
[24] See APPENDIX 2, Figures 25 & 26

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6.5. Conclusions and comments

After examining the motivation for all four categories of structured products separately we can make some conclusions on how these motives differ / work for each underlying asset.

First of all we understand that the principal protection term is of great importance, despite whether the underlying asset is an interest rate or a foreign exchange rate. Yet, we recognize that when an underlying asset is more risky by its nature, this term becomes even more attractive, since investor has the opportunity to participate in riskier markets without putting the principal at risk.

Secondly, we observe that the riskier the market of the underlying asset, the more enhanced is the promised return. Additionally, the riskier the payoff function of the structured product, the more attractive is the predetermined coupon to be paid. Obviously, the rate of return of a short-tenor interest rate-linked range accrual note with wide ranges cannot be as enhanced as the one of a two-year foreign exchange-linked product with a knock-out event. In later cast the investor undertakes bigger risk, hence he wishes to be compensated accordingly.

Finally, we realize that the basic benefits of structured products as discussed in Chapter 3, apply for all four categories. More specifically, diversification, hedging, leverage, participation in markets that are not otherwise easily accessed, view on the markets, all these are motives concerning structured products in total, irrespective of the underling asset the product is structured up on.

As far as it concerns the underlying asset time series as a motive / indicator of a structured product performance, we observed that history prices cannot always indicate accurately, or even correctly, the future performance of an instrument. Although summary statistics of the underlying assets can give an indication on the future performance, hence should not be taken into account by an investor without skepticism. However, we can make some comments:

- The underlying assets' time series of long-term structured products tend to have worst Sharpe ratio, compared to short-term structured products. However, short-term

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structured products tend to perform better[25]. Although this sounds irrational, nevertheless it can be explained. Abnormalities like Kurtosis, fatter tails and higher peaks, or Skewness on the distribution can be a problematic for the Sharpe ratio, since Standard Deviation doesn't have the same effectiveness when these problems exist.

ü Products with higher Historical Volatility tend to have better performances. This conclusion concerns the structured products of our sample, meaning the results could be affected by the specific payoff functions used, the specific underlying assets, periods etc.

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[25] The period of time that we presume as “short -term” can fluctuate, depending on the underlying asset. For example, for an Interest rate-Linked structured product, short tenor could be 1 or 2 years, while for a FX-Linked product short tenor could be 1 month.

APPENDIX 1

Theoretical frame of the study

The theoretical background for this study will be presented in this Appendix. Particularly, we explain the statistical tools we used to evaluate the data sets.

As explained in Bluman (2003), the **Mean**, also known as the arithmetic average, is found by adding the values of the data and dividing them by the total number of values.

$$\overline{X} = \frac{X_1 + X_2 + ...+ X_n}{n} = \frac{\Sigma \mathrm{X}}{n} \quad \textbf{(1)}$$

, whereby

n represents the total number of values in the sample and

X_i represents the values of the data

Also, according to Bluman, in order to calculate the variability of a data set, usually someone can use three measures: range, variance and standard deviation. For the purposes of our study we used Standard Deviation but the Variance will be shown firstly, since it is crucial for its definition. Variance is the average of the squares of the distance each value is from the mean. The symbol usually is the σ² and the formula is

$$s^2 = \frac{\Sigma(\mathrm{X} - m^2)}{n} \quad \textbf{(2)}$$

, whereby

n represents the total number of values in the sample

μ represents the Mean and

X_i represents the values of the data

Standard deviation measures the risk of an instrument, whether it is a stock, a future or a portfolio and is measured by the square root of the Variance. The corresponding formula is

$$s = \sqrt{\frac{\Sigma(\mathrm{X} - m^2)}{n}} \quad \textbf{(3)}$$

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Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or a data set, like daily returns of a stock's price, is symmetric if it looks the same to the left and right of the center point. The Skewness for a Normal distribution is zero, and any symmetric data should have Skewness near zero. Negative values for the Skewness indicate data that are skewed left, which means that the left tail is long relative to the right tail. Positive values for the Skewness indicate data that are skewed right, which means that the right tail is long relative to the left tail.

For univariate data $Y_1, Y_2, ..., Y_n$ the formula for Skewness is

$$Skewness = \frac{\sum_{i=1}^{N}(Y_i - \overline{Y})^3}{(N-1)s^3} \tag{4}$$

, whereby
$\overline{Y}$ is the Mean
s is the Standard Deviation and
N is the number of data points

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. Data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. Positive kurtosis indicates a "peaked" distribution and negative kurtosis indicates a "flat" distribution. The kurtosis for a normal distribution is 3.

For univariate data $Y_1, Y_2, ..., Y_n$ the formula for kurtosis is

$$Kurtosis = \frac{\Sigma_{i=1}^{N}(\mathrm{Y}_i - \overline{\mathrm{Y}})^4}{(\mathrm{N}-1)s^4} \tag{5}$$

, whereby
$\overline{Y}$ is the Mean
s is the Standard Deviation and
N is the number of data points

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The **Sharpe ratio** is a measure of the risk-adjusted return of an investment. The ratio describes how much excess return an investor is receiving for the extra volatility that she endures for holding a riskier asset instead of a risk-free asset. The higher the number, the better the investment looks from a risk/return perspective. The formula is as follows:

$$Sx = \frac{r_x - r_f}{StdDev_x} \qquad \textbf{(6)}$$

whereby,

X is the investment
rx is the annualized average rate of return of x
rf is the best available rate of return of a risk-free asset
StdDevx is the annualized standard deviation of rx

The returns measured can be of any frequency (i.e. daily, weekly, monthly or annually), as long as they are normally distributed, as the returns can always be annualized. Herein lies the underlying weakness of the ratio - not all asset returns are normally distributed.

For the purposes of this study, we calculated the Sharp ratio as follows:

- ü First we calculated the average daily return over a period of time. For this study we used historical closing prices of underlying assets for a period of time similar to the tenor of each structured product. For example, in the case of a product that has tenor three years, we took three-year daily historical data. We also calculated the standard deviation of the daily returns over the same period.
- ü Then we annualized the numbers. To annualize mean we multiplied it with 252, which is the number of observation for a year period. To annualize standard deviation we multiplied it with square root 252.
- ü We then calculated the **excess return**, which is the annualized return achieved in excess of the risk free rate of return available. This is the extra return an investor receives by assuming some risk.

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- The risk free return is the annualized return currently available on risk free investments. In our study, we took the short-term interest rate or swap rate that corresponds to each product's tenor, standing on each product's settlement date.
- Finally we calculated Sharpe ratio by dividing excess return with the annualized standard deviation**.**

Volatility can be defined as a measure reflecting the width of price fluctuations of the underlying asset during a certain period of time. It is often used to quantify the risk of the instrument over that time period but does not imply direction, since all changes are squared. An instrument that is more volatile is likely to increase or decrease in value more than one that is less volatile. Volatility is typically expressed in annualized terms, and it may either be an absolute number ($5) or a fraction of the initial value (5%).

In order to estimate the historical volatility, the underlying asset is observed at fixed intervals of time (e.g. every day, week or month). Since in our research we use the continuous compounded return, we will calculate the natural logarithm ratio of the underlying asset price at the end of the time period to the underlying asset price at the beginning of the time period, for each period.

$$u_i = \ln\left(\frac{S_i}{S_{i-1}}\right) \qquad \textbf{(7)}$$

whereby
Ui is the lognormal return
Si is the underlying asset price at the end of the ith interval

Then we calculated historical volatility as follows:

- First we found the variance and the annualized variance. Variance is equal to the sum of the square root of the daily return minus the mean divided by the number of observations minus one. When using data from a short time of period, the estimation of

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

the true mean can be inaccurate, so in order to avoid that we set the mean equal to zero. Consequently, we will divide by n and not n-1, so as the estimator to be unbiased.

ü Then we calculate volatility as the squared variance multiplied by squared root 252, since we use daily data.

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

Table 1: Summary Statistics of Structured Products' underlying assets time series

Product Name	Curr	Capital Protection	Category based on the underlying asset	Category based on the payoff function	Settlement Date	Maturity Date	Underlying asset	Mean	Standard Deviation	Skewness	Kurtosis	Sharpe ratio
Interest rate range accrual callable note	USD	100% capital guaranteed	Interest rate-Linked Note	Range Accrual Note	24/12/2004	24/12/2010	6M Libor	3.47	2.11	0.39	-1.50	-0.66
Interest rate range accrual callable note	EUR	100% capital guaranteed	Interest rate-Linked Note	Range Accrual Note	12/05/2004	12/05/2009	6M Euribor	3.42	0.95	0.18	-1.09	-0.61
Range accrual note	EUR	100% capital guaranteed	Interest rate-Linked Note	Range Accrual Note	14/12/2006	14/12/2007	6M Euribor	2.52	0.53	1.09	-0.25	2.01
Equity 3year capital guaranteed Absolute performance Basket	EUR	100% capital guaranteed	Equity-Linked Note	Dual Index Note	39065	40161	Indices Basket	5492.11	1111.17	0.05	-0.69	0.79
							Euro Stoxx50	*3056.52*	*532.62*	*0.23*	*-0.93*	*0.60*
							S&P 500	*1153.24*	*136.23*	*-0.48*	*-0.17*	*0.68*
							Nikkei 225	*12266.57*	*2664.65*	*0.40*	*-0.96*	*1.07*
3year capital guaranteed Equity-linked Autocallable worst off note	EUR	100% capital guaranteed	Equity-Linked Note	Multi Step-up Note	39062	40158	Equity Basket4	137.01	16.47	0.49	-0.16	0.63
							NestleSA	*316.43*	*33.22*	*0.51*	*-0.05*	*0.46*
							Novartis AC	*57.15*	*4.99*	*0.79*	*0.72*	*0.43*
							RWE AG	*37.47*	*11.21*	*0.18*	*-1.14*	*1.00*
12month Adajio on Euro Stoxx50	EUR	100% capital guaranteed	Equity-Linked Note	Leveraged floater Note	01/01/2005	01/01/2006	Euro Stoxx50	2805.20	87.60	-0.31	-0.58	0.38
Range accrual GROI on EUR/USD	USD	100% capital guaranteed	FX-Linked Note	Range Accrual Note	03/01/2007	28/12/2007	EUR/USD exchange rate	1.26	0.04	-0.27	-0.80	0.72
Range accrual knock-out GROI on EUR/USD	USD	100% capital guaranteed	FX-Linked Note	Range Accrual Note	04/01/2007	03/07/2007	EUR/USD exchange rate	1.25	0.05	0.16	-0.99	0.15
Range accrual GROI on EUR/USD	USD	100% capital guaranteed	FX-Linked Note	Range Accrual Note	05/01/2007	03/04/2007	EUR/USD exchange rate	1.29	0.02	0.56	-1.00	0.59
Commodity-linked note auto reddemed	EUR	100% capital guaranteed	Commodity-linked Note	Multi Step-up Note	38804	39900	Commodity Basket	1501.39	561.16	0.23	-0.98	0.97
							Copper	*2778.53*	*835.87*	*0.13*	*-0.92*	*1.52*
							Aluminium	*1682.56*	*835.87*	*0.13*	*-0.92*	*0.67*
							WTI crude oil	*43.08*	*11.75*	*0.42*	*-1.09*	*0.71*
3year Podium note linked to WTI	EUR	100% capital guaranteed	Commodity-linked Note	Range Accrual Note	02/01/2003	01/01/2006	WTI	27.46	3.78	-0.42	0.17	0.30
4year auto callable note linked to WTI	EUR	100% capital guaranteed	Commodity-linked Note	Multi Step-up Note	03/01/2005	03/01/2009	WTI	31.15	7.44	0.96	0.84	0.44

APPENDIX 2

1. Interest rate Range Accrual callable note, Issuer Banco Commercial Portuguese

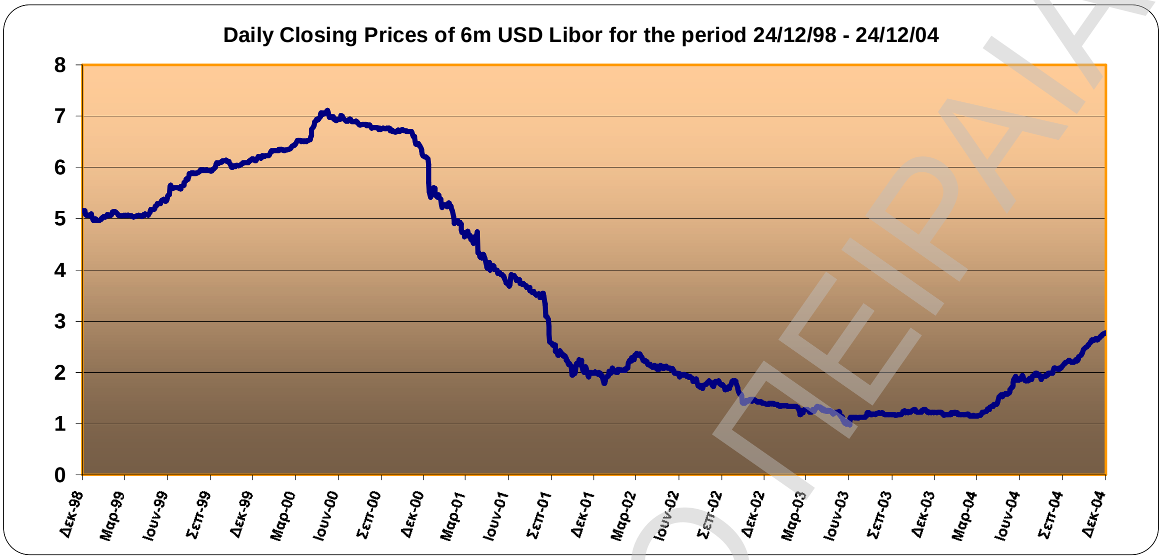

Figure 1: Daily closing prices of 6M USD Libor for the period 24/12/98 to 24/12/04

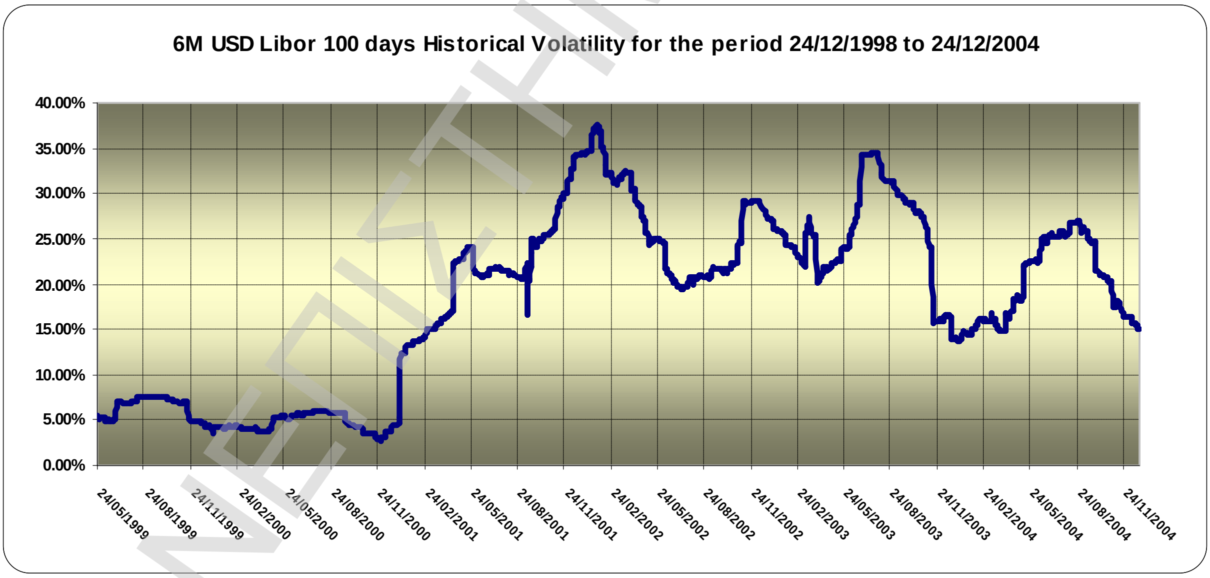

Figure 2: 100 days Historical Volatility of 6M USD Libor for the period 24/12/98 to 24/12/04

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

Interest periods	*24/12/04 - 24/12/05*	*24/12/05 - 24/12/06*	*24/12/06 - 24/12/07*
Ranges	**0- 3.75%**	**0- 4.25%**	**0- 4.75%**
Number of days in the Range	**129**	0	0
Total Number of observations	**252**	252	252
Coupon to receive per annum	**4,10%**	**0,00%**	**0,00%**

Table 2: Performance of Interest rate range accrual callable note for the period 24/12/04 to 01/07/07

2. Interest rate range accrual callable note, Issuer Banco Commercial Portuguese

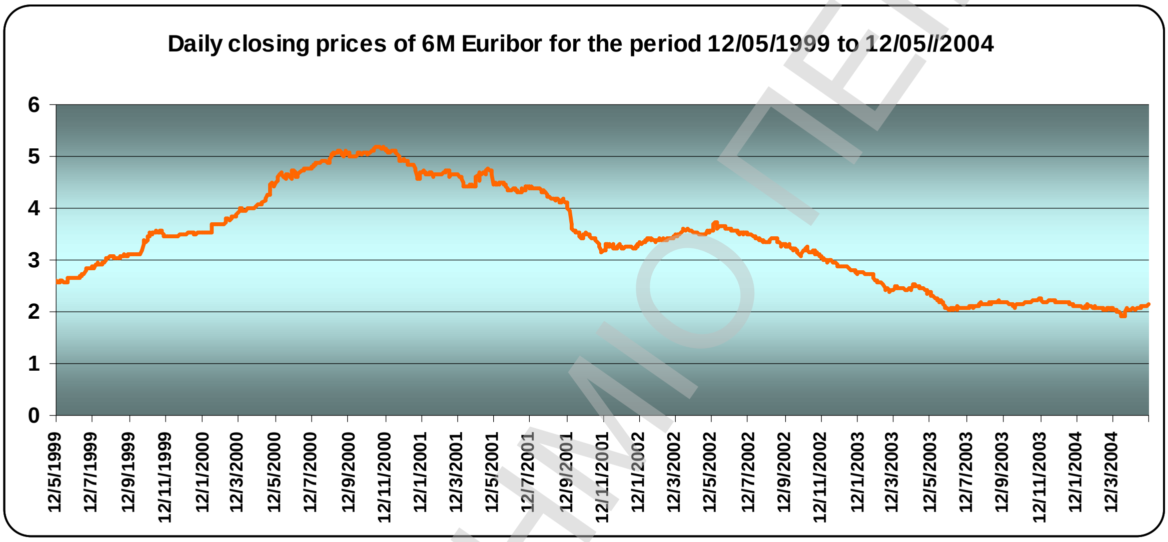

Figure 3: Daily closing prices of 6month Euribor for the period 12/05/99 to 12/05/04

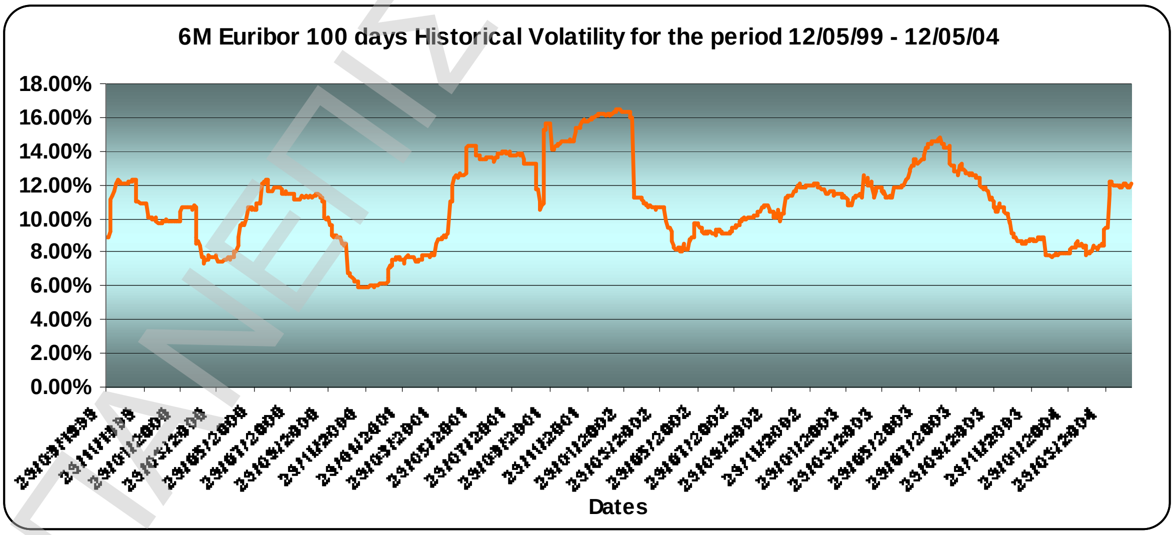

Figure 4: 100 days Historical Volatility of 6M Euribor for the period 12/05/99 to 12/05/04

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

Interest periods	*12/05/04 - 11/05/05*	*12/05/05 - 11/05/06*	*12/05/06 - 01/06/07*
Ranges	0- 3.05%	0- 3.55%	0- 4.05%
Number of days within the barriers	259	257	229
Total Number of observation	259	257	252
Coupon to receive per annum	**5,75%**	**5,75%**	**5,23%**

Table 3: Performance of Interest rate range accrual callable note for the period 12/05/04 to 01/06/07

3. Range accrual note, Issuer Rabobank

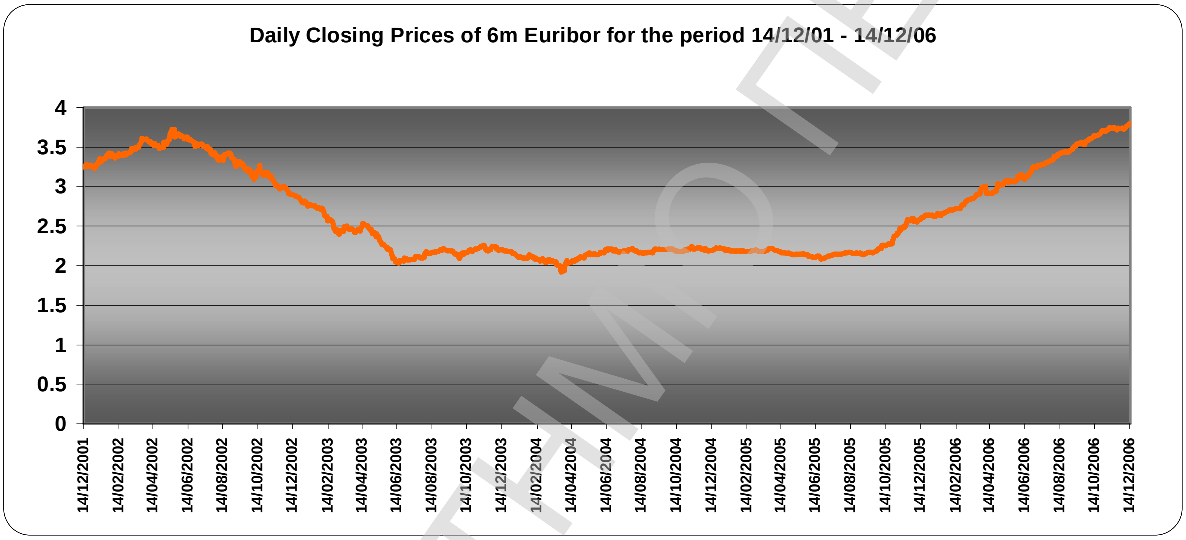

Figure 5: Daily closing prices of 6month Euribor for the period 14/12/01 to 14/12/06

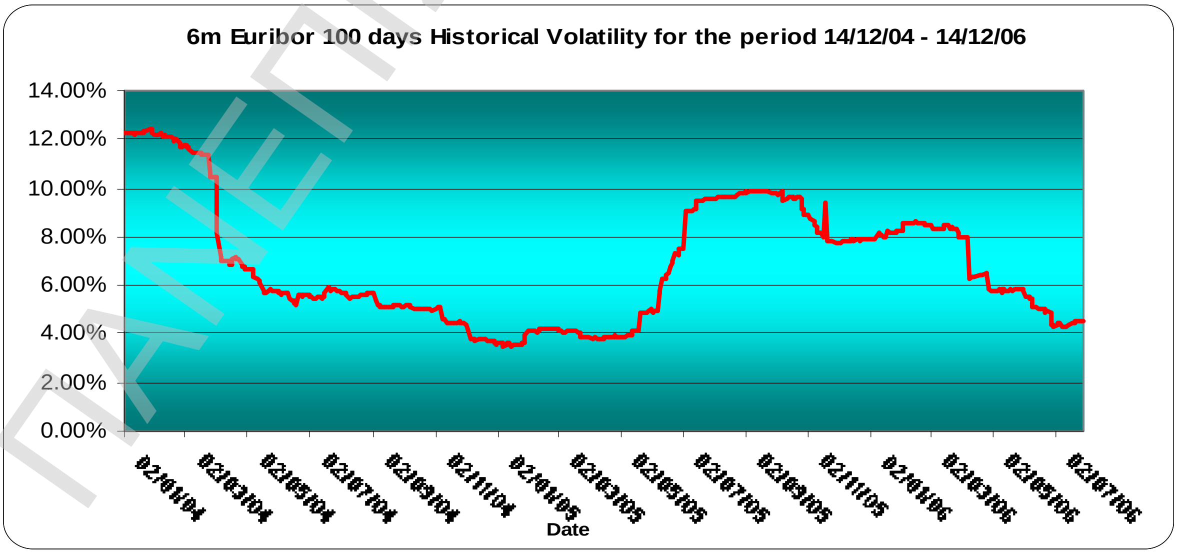

Figure 6: 100 days Historical Volatility of 6M Euribor for the period 14/12/01 to 14/12/06

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

Interest period	*14/12/05 - 14/12/2006*
Ranges	3,60% - 4,10%
Number of days within the Range	0
Total Number of observations	252
Coupon to receive per annum	**0.00%**

Table 4: Performance of the Range accrual note for the period 14/12/05 to 14/12/06

4. Equity 3 Year Capital Guaranteed - Absolute Performance Basket, Issuer BCP

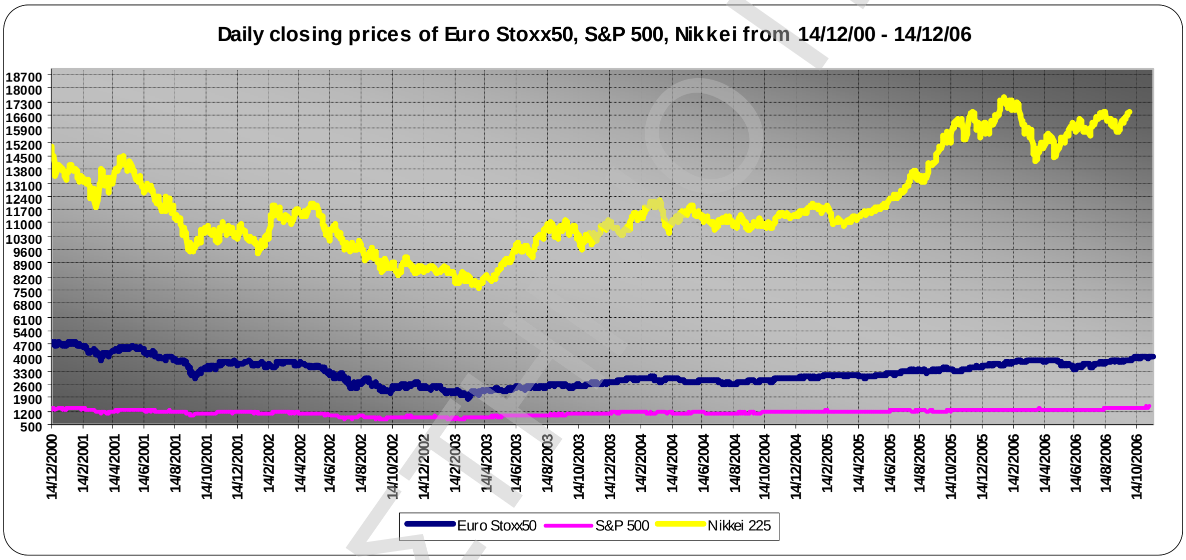

Figure 7: Daily closing prices of Euro Stoxx50, S&P 500, Nikkei 225 for the period 14/12/00 to 12/12/06

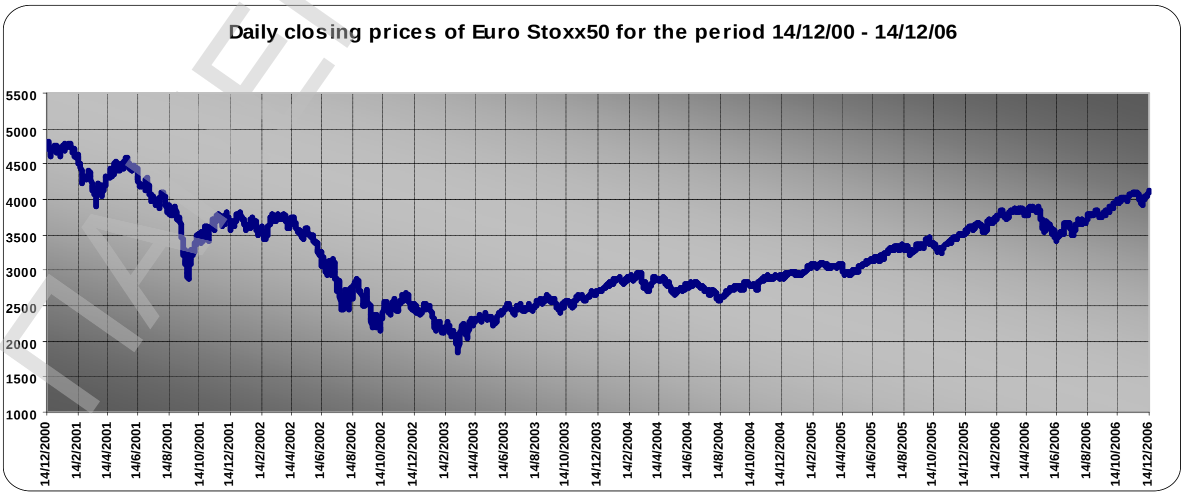

Figure 8: Daily closing prices of Euro Stoxx50 for the period 14/12/00 to 12/12/06

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

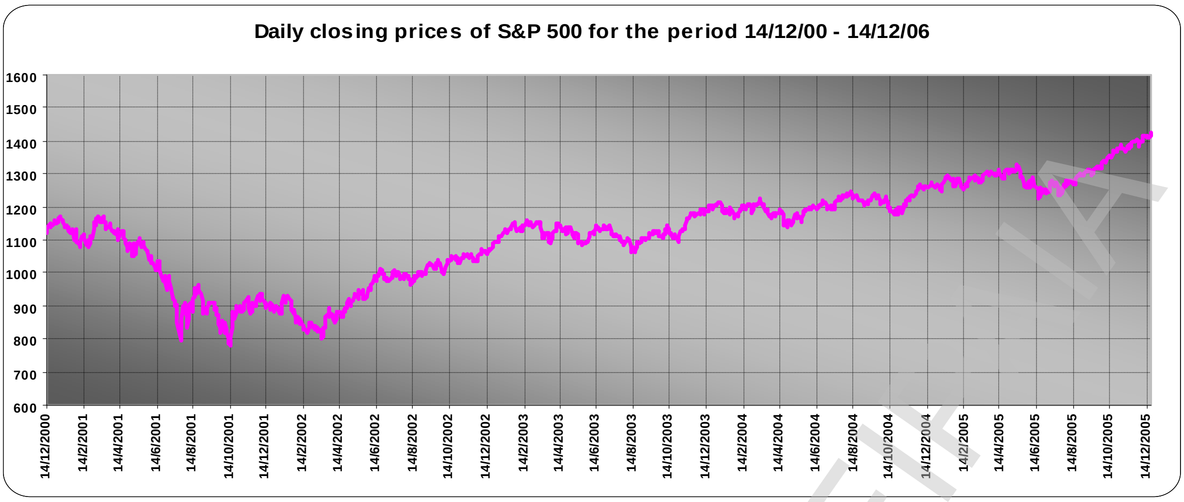

Figure 9: Daily closing prices of S&P 500 for the period 14/12/2000 to 12/12/2006

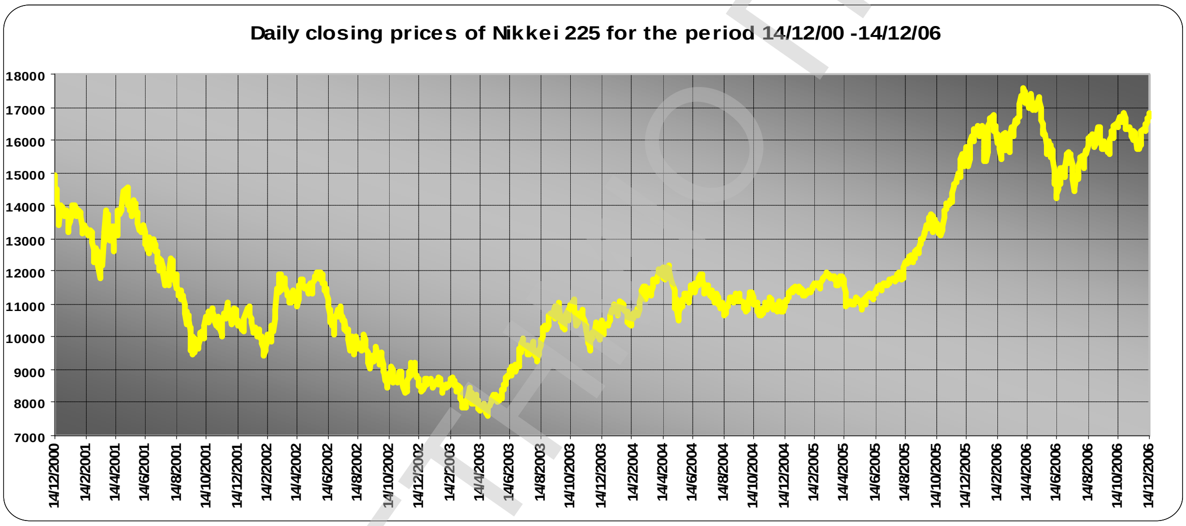

Figure 10: Daily closing prices of Nikkei 225 for the period 14/12/2000 to 12/12/2006

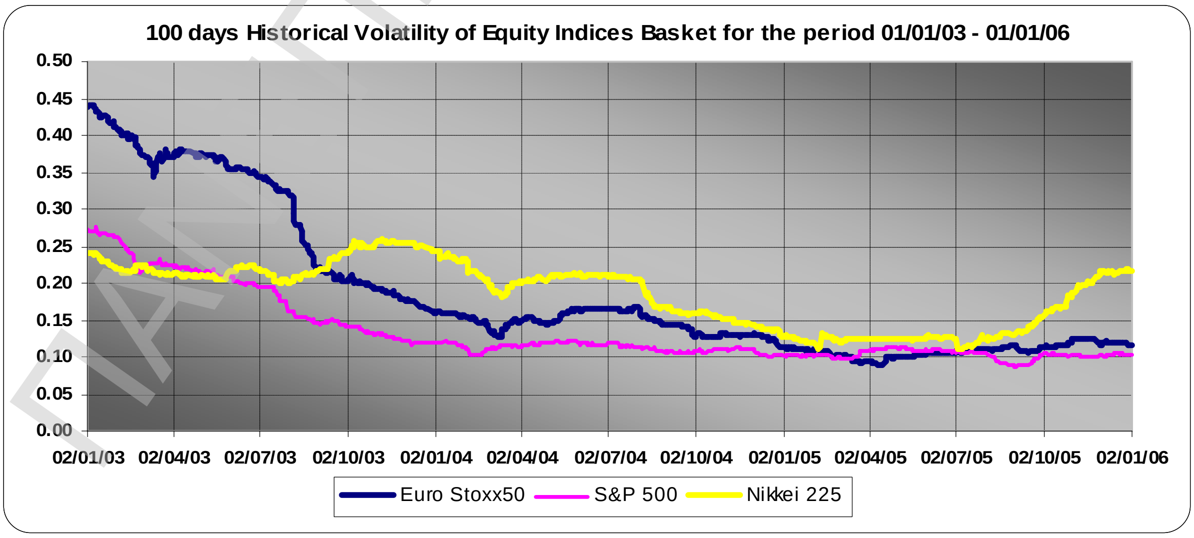

Figure 11: 100days Historical Volatility of the Equity Basket for the period 14/12/00 to 12/12/06

Index	*EuroStoxx50*		*S&P 500*		*Nikkei 225*	
Initial Index Price	14/12/2006	4118,84	14/12/2006	1425,49	14/12/2006	16829,2
Final Index Price	1/7/2007	4470,26	1/7/2007	1549,43	1/7/2007	18146,3
Index Performance		0,09		0,09		0,08
Basket Performance	8%					
Return to receive	**4%**					

Table 5: Performance of Equity 3 Year Capital Guaranteed - Absolute Performance Basket for the period 14/12/06 to 01/07/07

5. 3-years Capital Guaranteed Equity linked Auto-callable, Worst Off Note

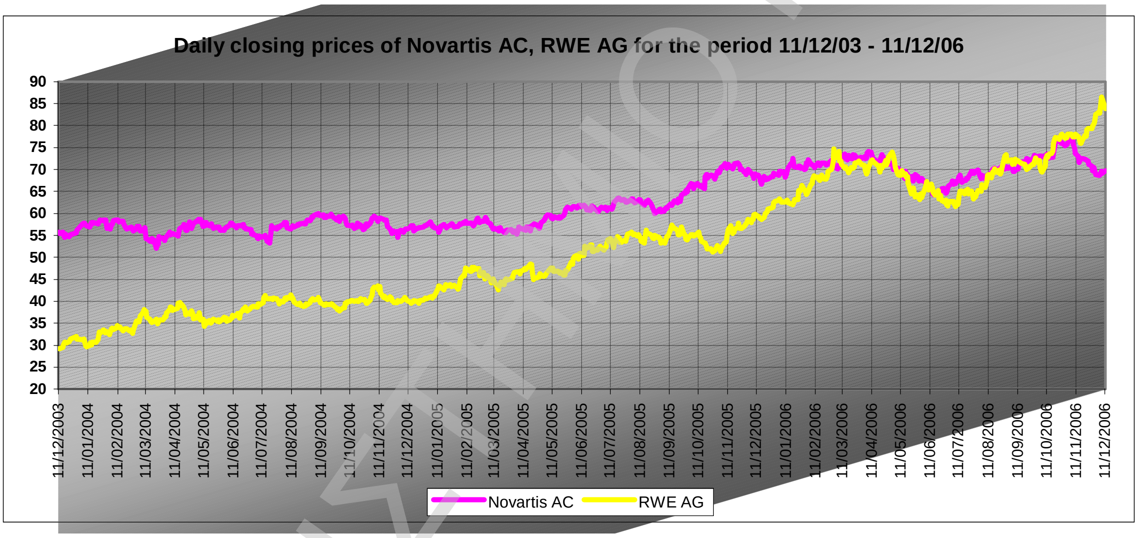

Figure 12: Daily closing prices of Novartis AC & RWE AG for the period 11/12/03 to 11/12/06

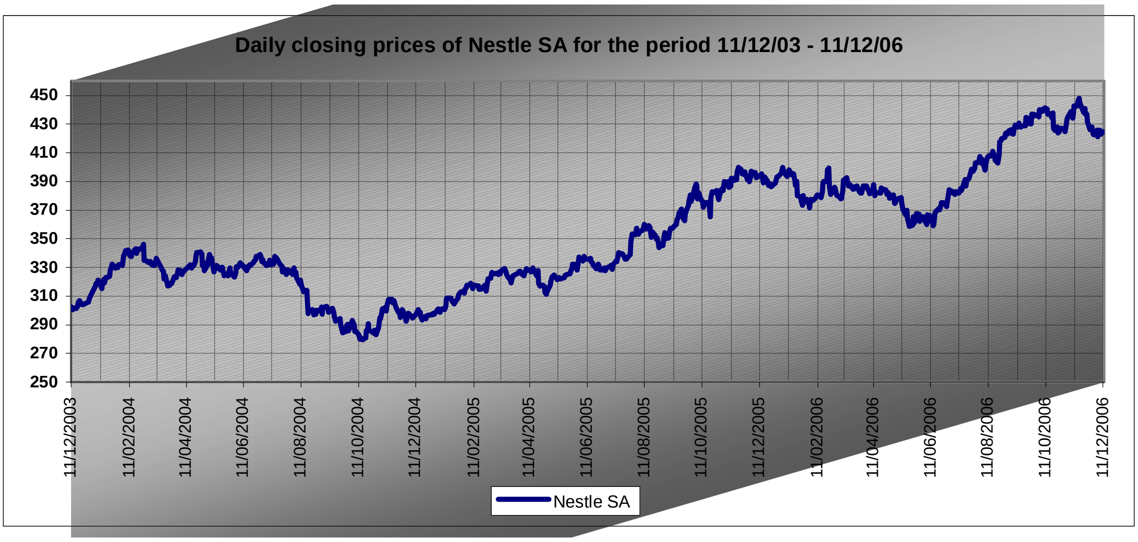

Figure 13: Daily closing prices of Nestle SA for the period 11/12/03 to 11/12/06

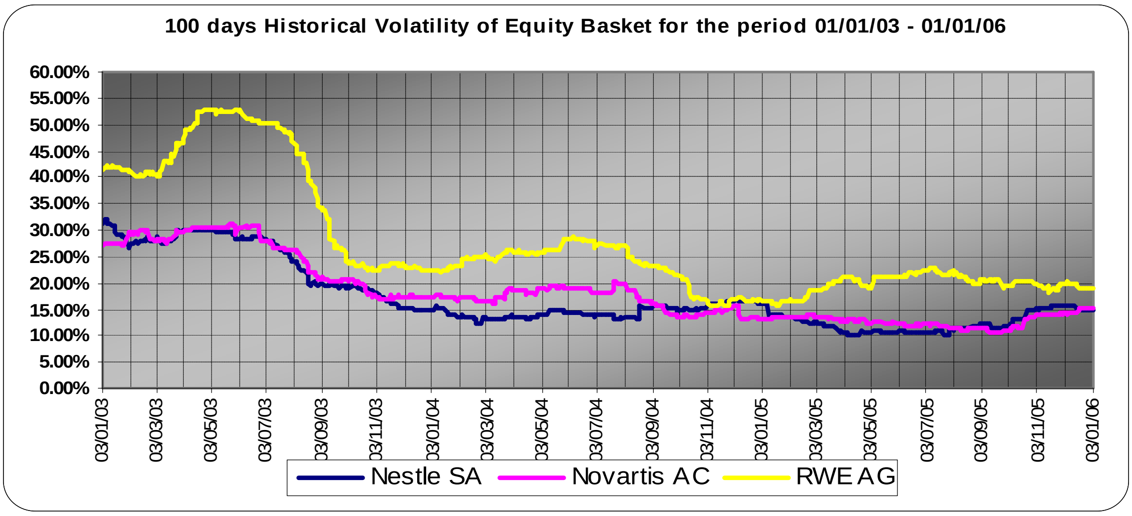

Figure 14: 100 days Historical Volatility of the Equity Basket for the period 11/12/03 to 11/12/06

Here we cannot measure the yield the structured product has given so far to the investor. According to the payoff function, we have to observe the three indices prices on 11/12/2007, and thus we cannot make any conclusion sooner.

Nevertheless, time series of the three equities, indicate that prices have increased since the initiation date, therefore is most probable that on first observation date the condition will be verified, the investor will receive 10% and the product will terminate. [26]

[26] Source Bloumberg

6. 12 Month Adagio on Euro Stoxx50, issuer Deutsche Bank

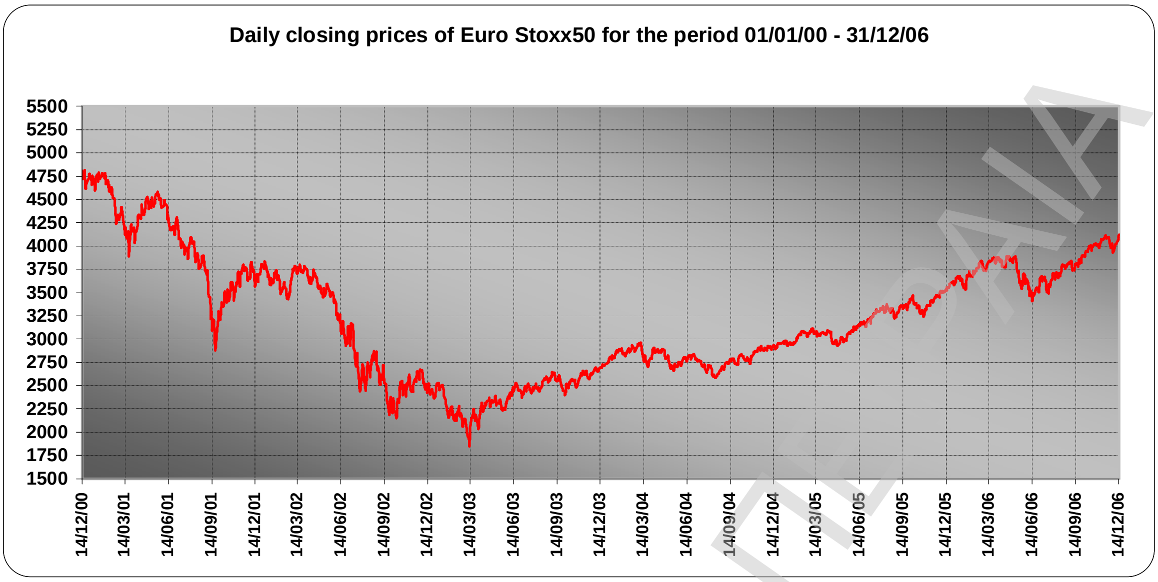

Figure 15: Daily closing prices of Euro Stoxx50 for the period 01/01/00 to 31/12/06

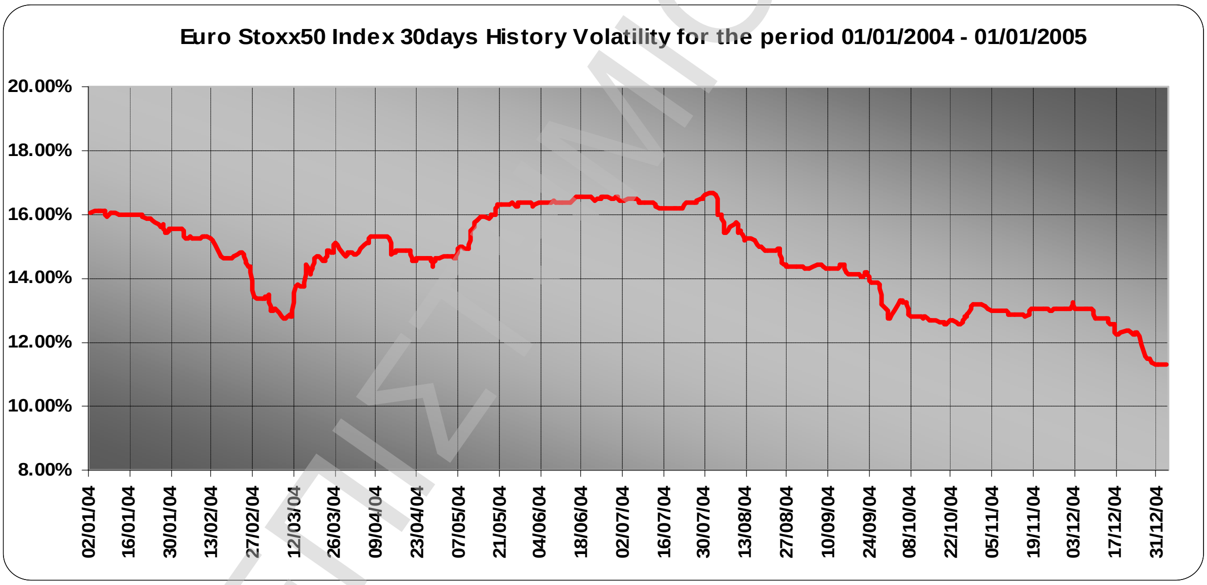

Figure 16: 30 days Historical Volatility of Euro Stoxx50 for the period 01/01/00 to 31/12/06

Period	01/01/05 – 01/01/06
Index Initial Price	2970,06
Lower barrier	2227,52
Higher barrier	3712,53
Min Closing price for the period	2924,01
Max Closing price for the period	3616,33
Coupon to receive on maturity date	**12m E+ 50 bps**

Table 6: Performance of 12 Month Adagio on Euro Stoxx50 Basket for the period 01/01/05 to 01/01/06

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

7. 1 Year Range Accrual GROI on EUR /USD, issuer UBS

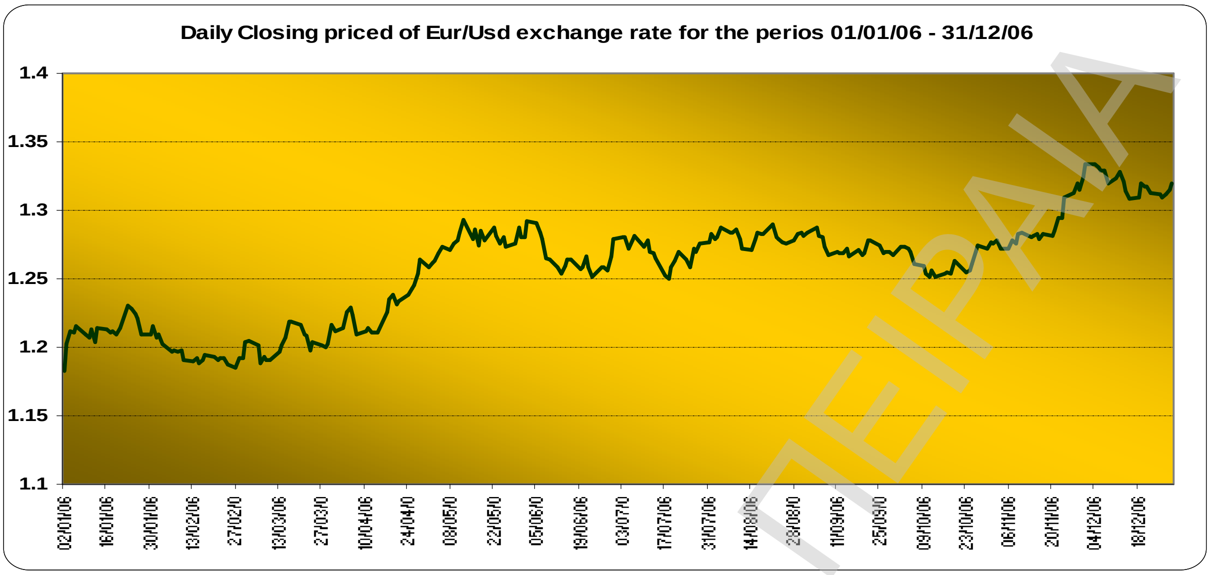

Figure 17: Daily closing prices of EUR/USD exchange rate for the period 01/01/06 to 31/12/06

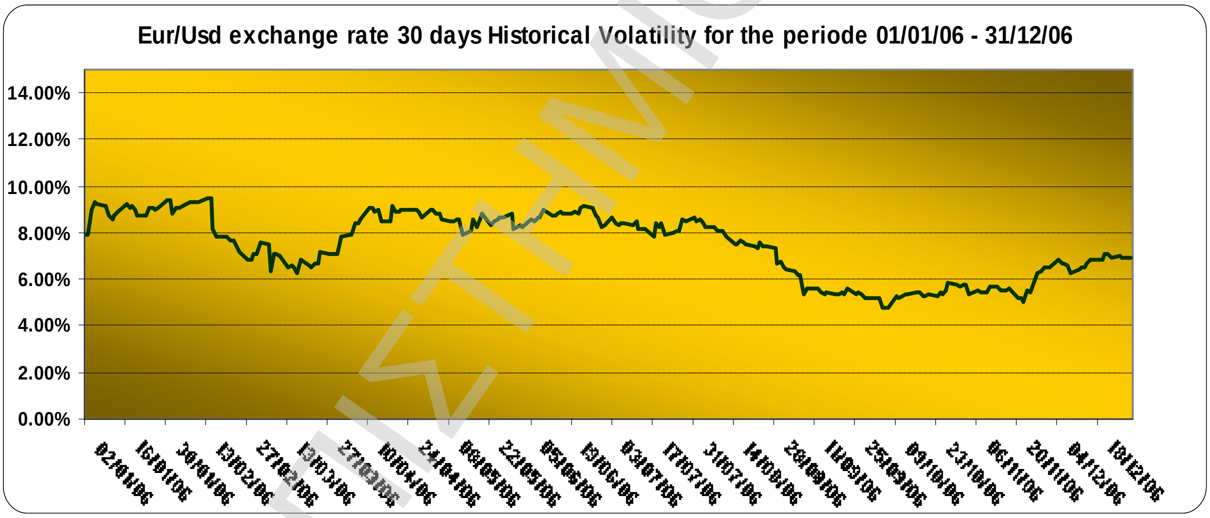

Figure 18: 30 days Historical Volatility of EUR/USD exchange rate for the period 01/01/06 to 31/12/06

Year	03/01/07 – 01/07/07
Spot Basis	**1.322**
Min Closing price for the period	1.2892
Max Closing price for the period	1.3651
Lower Barrier	1.270
Higher Barrier	1.340
Number of days within the Range	75
Total Number of observations	252
Coupon to receive on maturity date	**2.40%**

Table 7: Performance of 1 Year Range Accrual GROI on EUR /USD for the period 03/01/07 to 01/07/07

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

8. 6 month Range Accrual Knock-out GROI on EUR /USD, Issuer UBS

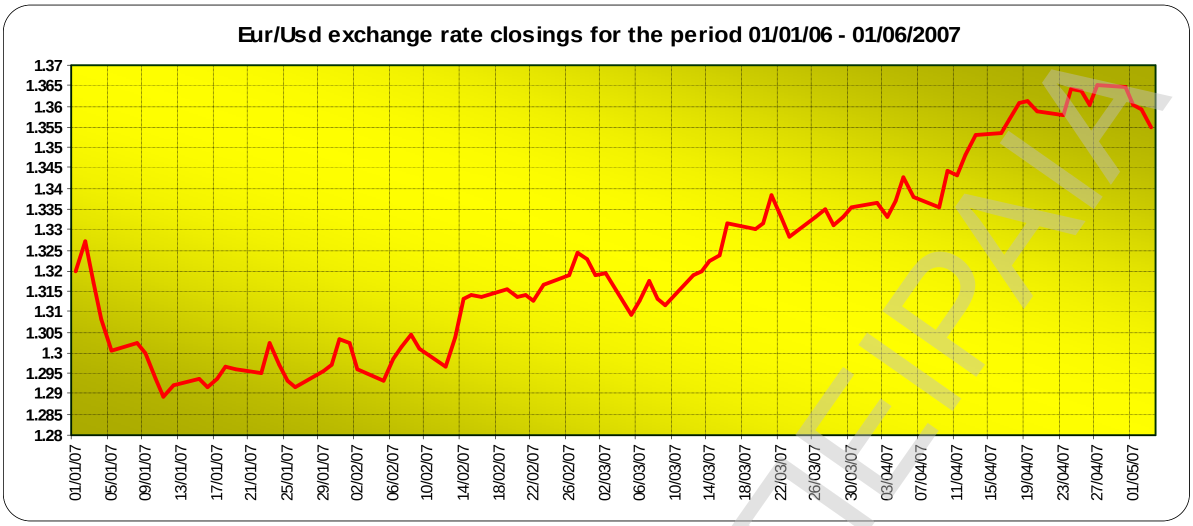

Figure 19: Daily closing prices of EUR/USD exchange rate for the period 01/01/06 to 01/06/07

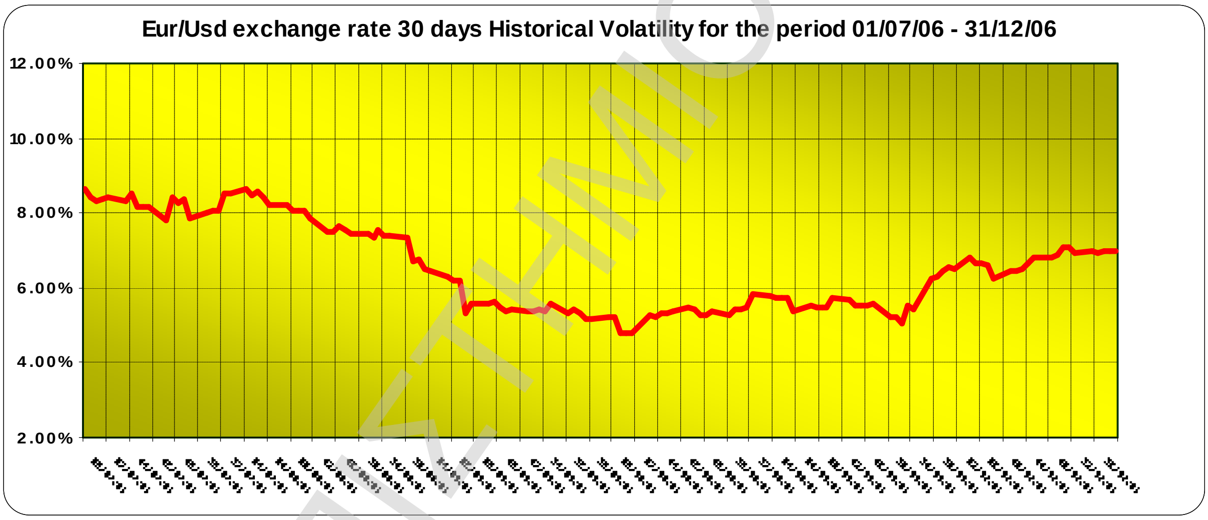

Figure 20: 30 days Historical Volatility of EUR/USD exchange rate for the period 01/07/06 to 31/12/06

Year	04/01/07 - 03/07/07
Spot Basis	**1,3234**
Min Closing price for the period	1,2915
Max Closing price for the period	1,3651
Lower Barier	1,265
Higher Barrier	1,35
Number of days in the Range	100
Total Number of days	126
Coupon to receive on maturity date	7.97%

Table 8: Performance of 6 month Range Accrual Knock out GROI on EUR /USD for the period 04/01/07 to 03/07/07

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

9. 3month Range Accrual GROI on EUR /USD, Issuer UBS

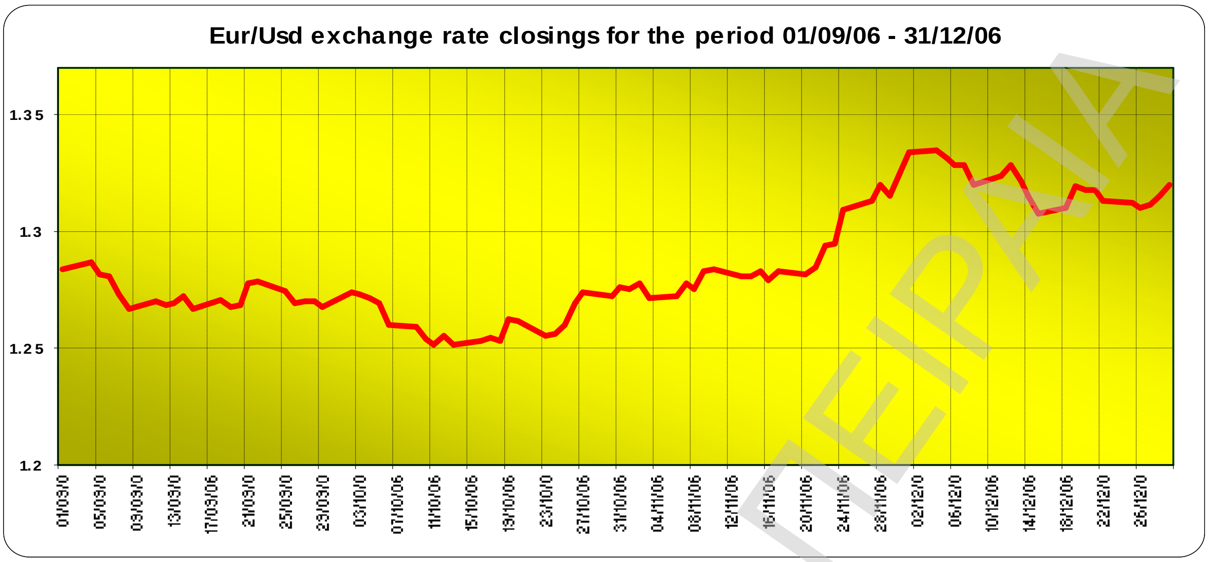

Figure 20: Daily closing prices of EUR/USD exchange rate for the period 01/09/06 to 31/12/06

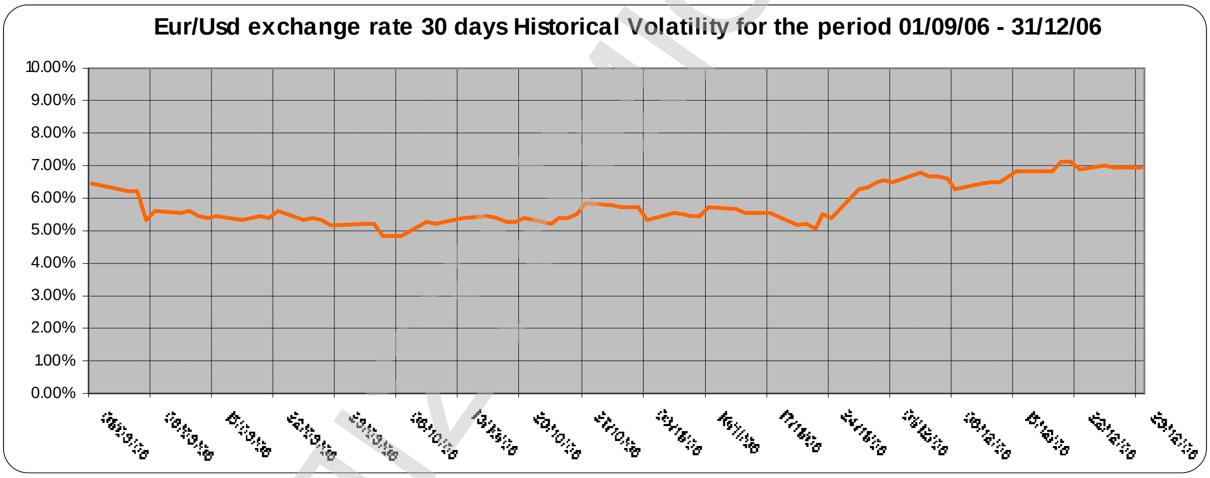

Figure 21: 30 days Historical Volatility of EUR/USD exchange rate for the period 01/09/06 to 31/12/06

Year	05/01/07 – 03/04/07
Spot Basis	**1,3262**
Min Closing price for the period	1,2892
Max Closing price for the period	1,3577
Lower Barier	1,263
Higher Barrier	1,35
Coupon to receive on maturity date p.a	**13,0342%**

Table 9: Performance of 3 month Range Accrual GROI on EUR /USD for the period 05/01/07 to 03/04/07

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

10. Commodity-linked note Auto redeemed, Issuer Banco Commercial Portuguese

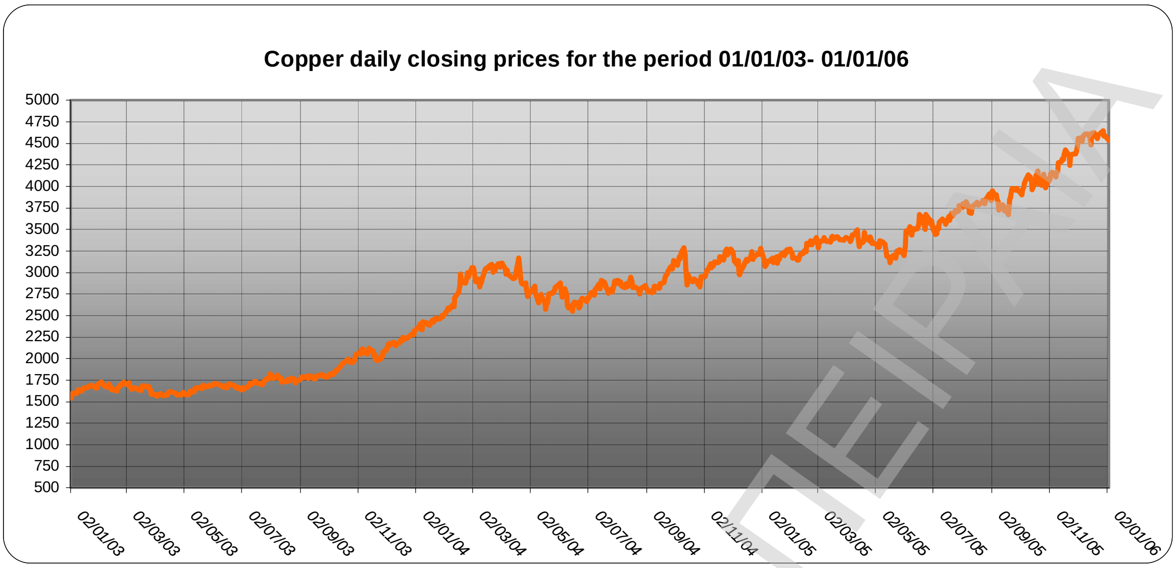

Figure 22: Daily closing prices of Copper for the period 01/01/03 to 01/01/06

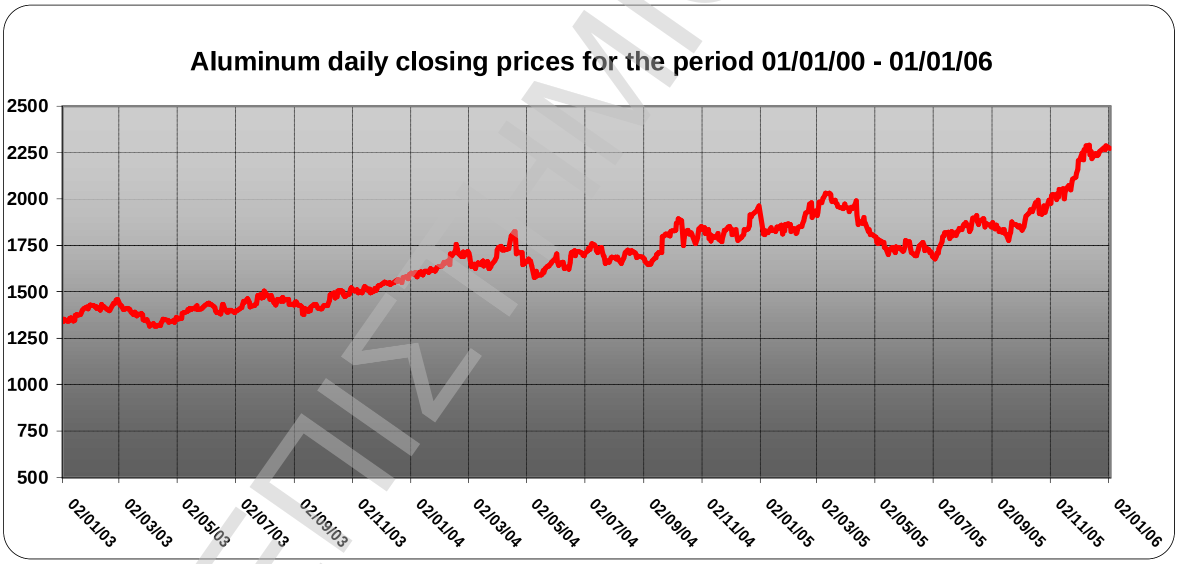

Figure 23: Daily closing prices of Aluminium for the period 01/01/03 to 01/01/06

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

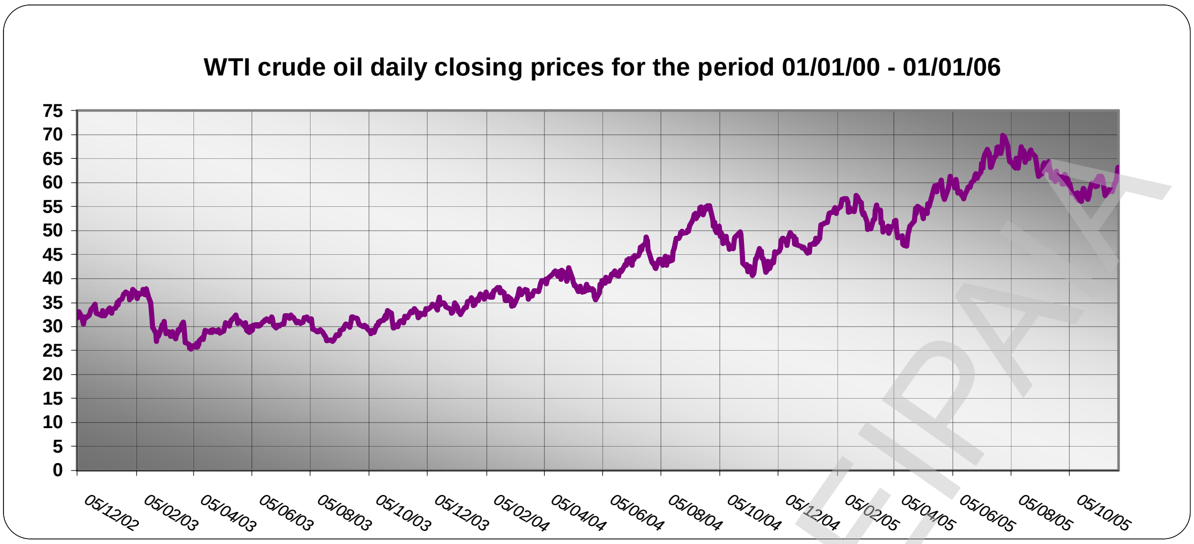

Figure 24: Daily closing prices of WTI crude oil for the period 01/01/03 to 01/01/06

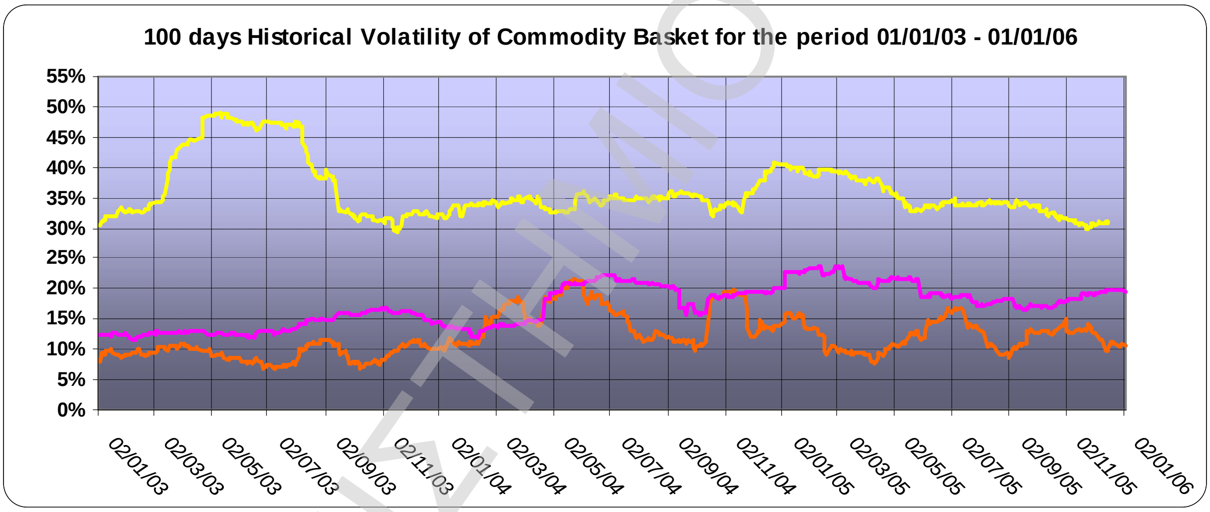

Figure 25: 100 days Historical Volatility of Commodity Basket (Copper, Aluminium & WTI crude oil) for the period 01/01/03 to 01/01/06

2006-2009	Observation periods	*Year 1*	*Year 2*	*Year 3*
	Initial Basket Price		7902,07	
	Initial Basket Price * 95%		7506,9665	
	Basket Price on Observation date	9515,08	-	-
	Coupon to recieve on termination or maturity	8,50%	-	-

Table 10: Performance of Commodity-linked note Auto redeemed for the period 28/03/06 to 28/03/07

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

11. 3year Podium note linked to WTI, Issuer Calyon–Credit Agricole Invest. Group

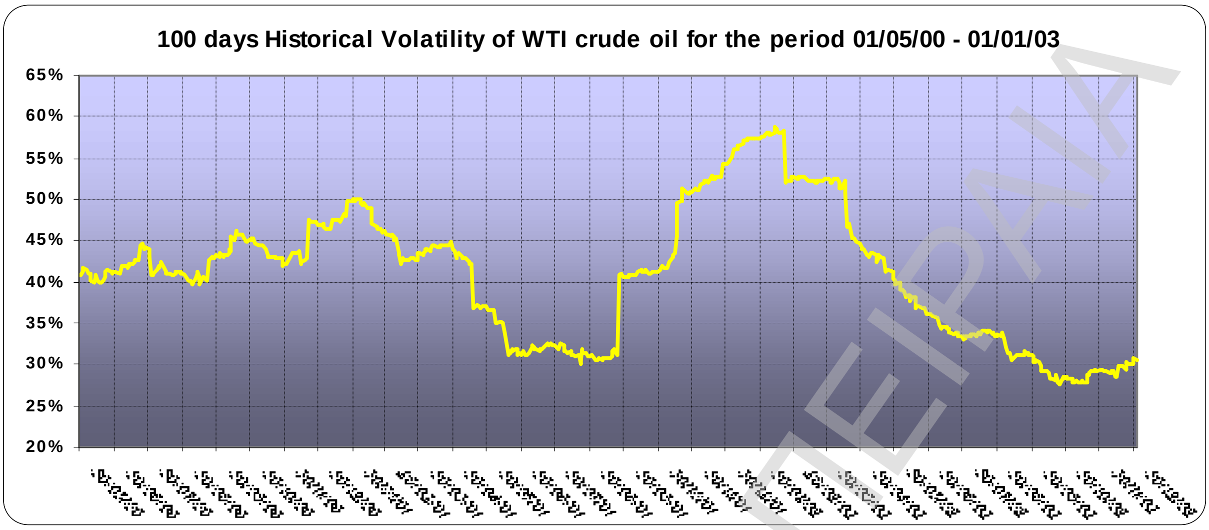

Figure 26: 100 days Historical Volatility of WTI crude oil for the period 01/01/03 to 01/01/06

Initial Price of WTI crude oil	31,85 (on 02/01/2003)					
Initial Price of WTI crude oil * 110%	35,04					
Interest payment periods	6m	1Year	1,5Year	2Years	2,5Years	3Years
WTI crude oil Price on observation dates	30,19	32,52	37,05	43,45	56,5	61,04
Coupon to receive on observation date	0,00%	0,00%	3,50%	3,50%	3,50%	3,50%
Total coupon payments received in three years	**14,00%**					

Table 11: Performance of 3-year Podium note linked to WTI crude oil for the period 02/01/03 to 01/01/06

12. 4year Auto call note linked to WTI, Issuer Calyon–Credit Agricole Invst. Group

Initial Price of WTI crude oil	42,12 (on 03/01/2005)			
Initial Price of WTI crude oil * 115%	48,44			
Interest payment periods	2006	2007	2008	2009
WTI Price on observation dates	63,14	-	-	-
Coupon to receive on termination / maturity	**6,00%**	-	-	-

Table 12: Performance of 4-year Auto call note linked to WTI crude oil for the period 03/01/05 to 03/01/09

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΕΙΡΑΙΑ

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